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THE HEADINGS OF THE CASCADE TUNNEL on the Great Northern Ry. met on Sept. 22 near the center. This tunnel is 13,252 ft. long, 24 ft. high and 20 ft. wide and was begun in 1897. The errors in alinement, as measured when the headings met, were as follows: alinement, 0.02 ft.; distance, 2 ins.; grade, 2¼ ins. The instrument work since the beginning of construction has been in charge of Mr. M. E. Reed, Assistant Engineer.

PROGRESS ON THE NEW YORK RAPID TRANSIT railway work was reported upon by Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., Chief Engineer, at the meeting of the Rapid Transit Commissioners on Sept. 20. This report contains the following general summary of the work:

The general contractor has now sub-contracted all of the line except the portion between 41st St., and Park Ave. and Seventh St. and Broadway, which section, being one of difficulty, is still under consideration. Actual work is in progress on all of the sub-sections, except those occupied by elevated structures, whose construction it is now necessary to begin, and on the tunnel beneath the Harlem River. There was some delay on the part of the American Bridge Co. in forwarding the steel contracted for with them. In view of the magnitude of the work this delay was probably unavoidable. The first shipment was received on Aug. 15, since which time it has been coming forward steadily, the 34th shipment having been reported to-day. In the meantime the contractors have utilized the opportunity to organize their forces and systematize their work, and they are now prepared to push the excavation already in hand and open new ones as the steel is received to put in place. The work of making the alterations in the sewer system, which has to be completed in advance of the subway itself, has been progressing steadily and satisfactorily. All of the large sewers which have to be changed or reconstructed are either in hand or completed, except the proposed sewer in the neighborhood of 45th St., and Broadway, work on which will proceed in connection with the section of the subway between 41st and 42d Streets. The large sewers actually completed aggregate about one mile in length.

THE NEW YORK RAPID TRANSIT RAILWAY route has been changed in respect to route of its downtown terminal loop. According to the original plan the loop passed entirely around the Post Office; the new plan provides that it shall be entirely north of the Post Office and wholly under City Hall Park. Regarding the extension of the road to Brooklyn the following general details have been given out:

So far as the engineer's work is concerned, some soundings have been taken in the East River and other general outlines are understood. The tunnel will go through Whitehall St., strike the Brooklyn side at Joralemon St., and extend to the Brooklyn City Hall and to the Flatbush station of the Long Island R. R. The South Brooklyn section will be taken up later unless there is a decided change in the plans. It has been estimated that the extension to Brooklyn from the New York City Hall as far as the Flatbush station will cost in the neighborhood of from $4,000,000 to $6,000,000. The Atlantic Ave. extension will be considered at a later period, and it is not unlikely that this proposed route, notwithstanding the apparent abandonment of its old plan by the Long Island R. R., may yet be built by that corporation, now controlled by the Pennsylvania, and sooner than the general public expects.

THE LONDON UNDERGROUND RAILWAY franchise, owned by the Charing Cross, Euston & Hampstead Underground R. R. Co., has been purchased by an American syndicate of capitalists headed by Mr. Charles T. Yerkes, of Chicago, Ill. The purchase price is stated to have been $500,000. According to the English newspapers the plans of the syndicate involve the expenditure of nearly $20,000,000 in developing an electric traction transit system for the city of London.

A NEW TRANSATLANTIC LINER of enormous dimensions is to be built by Harland & Wolff, of Belfast, Ireland, for the Hamburg-American Line. According to the press dispatches the new ship will be 750 ft. long and 76 ft. beam and will have accommodations for 2,000 passengers and 12,000 tons of cargo. Her speed will be 18 knots and she will be of the most improved construction throughout. The largest ocean vessel afloat to-day is the White Star steamship "Oceanic," whose main dimensions are: length 704 ft. and beam 68 ft. 4½ ins. The new Hamburg-American ship is to be completed in 1903.

THE TORPEDO BOAT "O'BRIEN" of the U. S. Navy was launched at the Crescent Shipyards, Elizabeth, N. J., on Sept. 24. The vessel is 175 ft. long, 17 ft. beam, and draws 4½ ft. She has a guaranteed speed of 26 knots an hour. She carries three torpedo-launching tubes and three rapid-fire guns. The engines are triple expansion, with four cylinders, 18, 27, 27½, 27½ ins. diameter by 18 ins. stroke, using steam at 250 lbs. pressure.

THE NEW SHIPBUILDING PLANT of the Risdon Iron Works, of San Francisco, Cal., is rapidly assuming material form. This company has purchased for its new plant the property of the Pacific Rolling Mill Co. This property consists of some 32 acres of ground, immediately adjoining the Union Iron Works, and has a deep-water frontage of over 1,700 ft. Application has been made to the Board of State Harbor Commissioners for a site for a new dry dock. This dry dock will be 500 ft. in length and 100 ft. in width. New wharves are now in course of construction. Several new steel-frame buildings are contemplated and large orders covering the structural materials for the following buildings have recently been placed: Machine shop, length 308 ft., width 100 ft., total lift over main floor 45 ft.; boiler shop, length 140 ft., width 180 ft., total lift over main floor 40 ft.; machine and ship blacksmith shop, length 300 ft., width 60 ft.; foundry, length 177 ft., width 160 ft.; ship joiner shop, length 140 ft., width 81 ft. The machine shop will be equipped with four electric traveling cranes with capacities of 50 tons, 20 tons, 15 tons and 10 tons. Each crane will be of the most modern type and equipped with 5-ton auxiliary hoists. The boiler-shop crane equipment will consist of one 60-ton, one 20-ton and one 10-ton electric traveling crane, each equipped with 5-ton auxiliary hoists. The foundry crane equipment will consist of one 30-ton and one 20-ton electric traveling crane with 5-ton auxiliary hoists. The ship blacksmith shop will be equipped with eight jib cranes of 5 and 10 tons capacity each. The machinery equipment throughout will consist only of the most modern tools. The entire plant, with the exception of the steam hammers in the blacksmith shop, will be operated by electricity, and contracts have recently been placed with the Independent Electric Light & Power Co., of San Francisco, to furnish power for this plant. Direct current will be used for the cranes and an alternating current for the machinery equipment. Separate motors will be installed in each department. The cost of electric power for operation of this plant for the first year will amount to over $30,000. We are informed that representatives of the company are now in Washington preparing estimates for the new battle-ships for the United States Navy and the company will be prepared to contract for at least two of the new vessels.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Philadelphia, Harrisburg & Pittsburg branch of the Philadelphia & Reading R. R., at Grantham, Pa., Sept. 25. Two freight trains collided head-on, resulting in the death of three men and the injury of two others. It is said that the accident was due to a disregard of train orders.

A FLOOD in the Colorado River on Sept. 17 partially destroyed the town of San Saba, Tex., about 40 miles north of Austin. The flood was reported to be much greater than the one that wrecked the Austin dam last spring.

THE NUMBER OF FATALITIES in the Gulf storm of Sept. 8 is found to be largely increased over earlier estimates. The Galveston relief committee estimates the number of deaths in that city as in excess of six thousand to seven thousand, and Governor Sayers of Texas, in an official statement on Sept. 19, set the loss of life in all Texas at not less than 12,000, with a property loss of over $20,000,000. This makes the disaster much the most far-reaching in its fatalities of any that has ever occurred on this continent.

THE EFFECT OF THE GALVESTON STORM upon the harbor work and fortifications at that point is to be investigated by a Board of Engineer Officers, consisting of Col. Henry M. Robert, Major H. M. Adams and Capt. Chas. S. Riche, Corps of Engineers, U. S. A. The Board is to convene at Galveston on Oct. 15.

THE NARROWNESS OF THE CHICAGO RIVER has again resulted in an accident to one of the large lake steamers. The vessel became stuck in the passageway between the old Wisconsin Central Ry. swing-bridge and the abutment of the new bascule bridge and remained there 24 hours, despite the most energetic efforts, before she could be set free. The trains of three railways and a large fleet of grain vessels were delayed 24 hours by the accident.

THE MONTEVIDEO HARBOR WORKS, costing $12,000,000, will probably be carried out by either English or French contractors. At the date for closing the receipt for bids, Aug. 31, 1900, bids had been received from three British and four French firms. No bid was received from an American contractor.

THE CANALIZATION OF THE MOSELLE in order to make it navigable for the large Rhine boats from Metz to Coblentz is advocated by a Congress recently held at Metz. This Congress was composed of 200 delegates of the Imperial Government, the Chambers of Commerce of Alsace-Lorraine and the Rhenish provinces, and others, and it pronounced itself in favor of the project and transmitted its resolution to the German Government.

A ROLL-RELIEVING DEVICE for quickly relieving the pressure on the rolls of plate rolling mills has been invented by Mr. Chas. L. Huston, Vice-President of the Lukens Iron & Steel Co., of Coatesville, Pa., and has been applied to a new three-high universal mill recently built for that company by the A. Garrison Foundry Co., of Pittsburg. As described in the "Iron Trade Review" of Sept. 20, the device consists of a pair of wedges with faces at an agle of 30°, lying between the bearings of the roll and the cap. These wedges can be slackened by right and left hand screws, which are rotated by a rack and pinion operated by a hydraulic cylinder. The roll train fitted with this device has been in use for several months and the device has several times prevented serious accidents.

WATER WASTE AT HALIFAX, Nova Scotia, has increased the consumption to such a degree that the present supply is insufficient for the city's requirements. The City Engineer, Mr. F. W. W. Doane, in a report to the Mayor, states that if the waste is not restricted an additional supply must be secured at a cost of not less than $1,000,000. He advises the general introduction of meters and says:

The last inspection showed hundreds of places in which water was running to waste unnecessarily. Inspection does no good and would require a large staff. As soon as the inspector leaves the premises the water runs as usual. The adoption of meters seems to be the only sure cure for waste and if the waste is stopped the supply is ample. A meter placed on a South End wharf registered 1,400,000 gallons the first month and about 12,000 gallons since. At a stable in the center of the city the month's reading was 40,000 gallons, the reading now is 4,000. A wasting water closet in an Inglis St. house used 1,000 gallons a day when the meter was put on; it now averages six gallons.

Providence, R. I., a city which requires a large quantity of water for manufacturing purposes and has 80% of supplies metered uses 54 gallons per head of the population. Fall River, another manufacturing city, with all supplies metered, uses 34 gallons. Halifax uses nearly 200 gallons. If the water running into Halifax were used at the same rate per head as in Fall River the supply from the high service alone would be sufficient for the whole city. In the face of this it seems absurd to talk of an expenditure of $1,000,000 besides the necessity of tearing up the streets to alter the distribution pipes so that more water could be brought in.

It is claimed that water is free, but it has cost Halifax $1,100,000 to put it into the taps. No man questions the necessity of measuring gas, electric current, etc. No man thinks it a hardship that boards of health prevent any citizen from doing anything to cut off an ample, pure and free supply of fresh air from his neighbor. It is an injustice for a man to take his water supply from him and throw it away. High service householders are daily taking from the pipes water which they do not need and do not pay for, but which belongs to others who do need it and do pay for it but do not get it. Meters will stop the carelessness of consumers and use of bad and exposed plumbing which causes the great waste.

EXPORTS OF MANUFACTURES INTO CANADA from the United States during 1899 continued to exceed those from Great Britain, notwithstanding that the latter country enjoyed the advantage of the preferential tariff rate of 25% less than any other country, which was enacted in 1898. A recent copy of the "Canadian Manufacturer" calls attention to the fact that the imports of dutiable articles into Canada from the United States in the fiscal year 1899 aggregated over $44,000,000 and from Great Britain less than $28,000,000, and that the United States is furnishing a much larger amount of manufactures of iron and steel than the United Kingdom, and adds:

The preponderance of trade is overwhelmingly in favor of American manufactures and, tariff preference in favor of British goods to the contrary notwithstanding, American manufacturers are taking the cream of the business. Is it possible that British manufacturers are entirely unable to compete in the Canadian market?

SOME ENGINEERING RELICS UNEARTHED NEAR BOSTON.

By Frederic L. Winslow.*

The abolition of the grade crossings at East Somerville, Mass., by the Boston & Maine R. R., necessitated the removal of about 850 ft. of the 30-in. wrought-iron cement-lined pipe which has supplied the district of Charlestown since 1870.

This pipe has given remarkably good service compared with similarly-made smaller pipes which gave out years ago. Except where this pipe was laid in new filling, it has rarely leaked, unless, as has occurred more than once, it has been mistaken by laborers for a sewer. The interior of the pipe was remarkably clean. In constructing the pipe, three 3-ft. lengths were joined in the shop. Over both of the riveted joints a clamp sleeve of curved section was placed, the space between the sleeve and the outside surface of the main being filled with neat cement. These 9-ft. lengths were joined together by a closely-fitting sleeve 8 ins. in width. The outside of the pipe was covered with 2 ins. of cement and the interior was lined with 1¼ ins.

30-In. Wrought-Iron Cement-Lined Water Main, Laid at East Somerville, Mass., in 1870.

The circumferential rivets were 5¼ ins. pitch, and the longitudinal rivets were in two rows, staggered, 2 ins. pitch. Seams were lapped 3 ins. The rivets were 7-16-in. diameter, and were hammered nearly flush with the outside of the pipe. The wrought-iron composing the pipe was 0.16-in. thick, and in spots had rusted to 0.11-in. in thickness. The usual pressure in this pipe was 50 lbs. The cement taken from the pipe exhibited only slight tensile strength.

Another example of early engineering work was recently uncovered in excavating in East Boston for the approach to the East Boston tunnel, and is illustrated herewith. It is an underground reservoir designed as a reserve supply in case of fires, but probably also intended for use, temporarily at least, for domestic supply.

The reservoir was built in 1849, and was fed by a 2½-in. lead pipe laid across the main ship channel, a distance of about 3,000 ft. The reservoir is circular in plan, a pier in the center carrying the arches from the outer wall. It is 18 ft. in diameter and 16 ft. in depth, having a capacity of about 30,000 gallons. The lead pipe referred to was broken about one year after being laid, and as the main pipe line was then being laid to East Boston it was not repaired.

As seen in the photograph, the reservoir was located directly in the street, and the electric car tracks ran directly over it. The consequences of a failure of the roof might have been serious, but, fortunately, the masonry was of good quality, although it was doubtless never designed to carry the load that has been imposed on it in recent years.

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A 600-HP. TWO-STROKE CYCLE GAS ENGINE USING BLAST-FURNACE GAS.

(With full-page plate.)

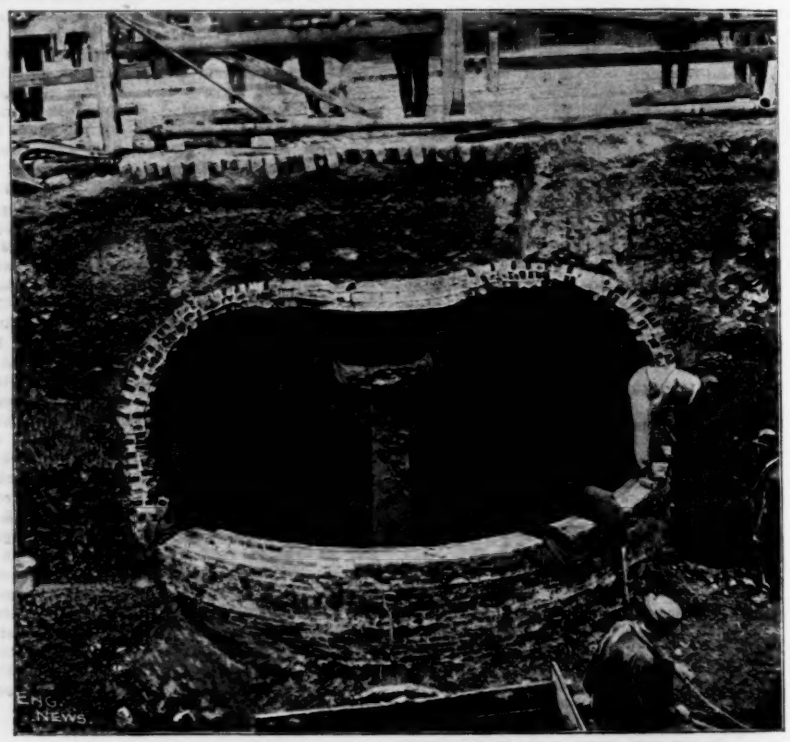
In our issue of July 19 we described and illustrated a four-stroke gas engine of 600 HP., designed to use blast-furnace gas. The total weight of this motor, exclusive of the blowing engine, is 127 tons, of which 33 tons is in the flywheel. It is, then, a very heavy engine for the power developed, and one is naturally led to enquire into the possibility of using a two-stroke cycle engine instead, in which the weight for a given power is reduced, both because of the greater activity of the working cylinder and the lessened necessity for weight in the flywheel. Such machines have been built and are in satisfactory operation in Europe. In a recent issue of the "Zeitschrift des Vereines Deutscher Ingenieure," Herr E. Meyer, of Göttingen, Germany, after describing the four-stroke cycle engine above referred to, gives a description of a two-stroke cycle engine of the same HP., from which description the following is abstracted:

Next to the four-stroke type the two-stroke engines have played a large part in the development of large gas engines. The two-stroke engine shown in the accompanying inset sheet was built after the Oechelhauser system by the Berlin-Anhalt Machine Co. It was the first 600-HP. gas engine to be actually erected and placed in operation. An indicator card taken from its working cylinder is shown in Fig. 1. It will be seen that compression, explosion and expansion take place exactly as in a four-stroke cycle machine, but that the exhaust and suction strokes are omitted. The exhaust of the products of combustion takes place during the last eighth of the expansion stroke, and the introduction of the fresh working mixture during the first eighth of the compression stroke. Since the products of combustion are not forced out by the piston, scavenging must be accomplished by introducing air under pressure, which latter is taken from the pipes supplying the blast to the blast-furnace. The fresh working mixture is furnished by a special pump, which draws in air and gas and then forces them into the working cylinder.

The working cylinder of the Oechelhauser engine is open at both ends, and contains two pistons, which move in opposite directions. The crank shaft is three-throw. The forward piston is connected to the middle crank by a piston rod, crosshead and connecting rod, while the rear piston is connected to the two remaining cranks by a piston-rod, yoke, side-rods, cross-heads and connecting rods. As the engine is shown on the inset, the pistons are at the inner end of the stroke, leaving only the compression space between them, that is, compression is completed. By means of an electric spark, obtained from storage batteries and a spark-coil, the mixture is fired and the pistons are driven outwards. When [illegible] have nearly reached the end of the stroke the forward piston opens the exhaust ports, which are distributed around the forward end of the cylinder and are connected to the exhaust pipe (See section c-d upon the inset), through which the products of combustion can escape. At the same time the rear piston uncovers ports that are connected with the scavenging-air reservoir. The latter has been supplied from the furnace blast pipes with an exactly measured quantity of air, which is under a pressure of about 0.7 atmosphere. This streams through the ports, which are arranged symmetrically around the circumference of the cylinder and drives the products of combustion before it and out through the exhaust ports. While this is taking place, however, the further movement of the engine causes the rear piston to uncover the admission ports, back of the scavenging ports, and the fresh working mixture flows in.

The feed pump that furnishes the fresh mixture is mounted upon the frame of the engine back of the working cylinder, and is operated by a prolongation of the rear piston rod. It is double-acting and is provided with rotating valves. Gas and air are drawn through the mixing device and the suction pipe and the mixture is forced through the pressure pipes to the admission ports under about ⅓-atmosphere pressure. From there the mixture flows through the whole length of the cylinder. Immediately all the ports are closed by the return of the pistons, which takes place soon enough to prevent any of the explosive mixture from passing out through the exhaust ports. As soon as the ports are closed compression commences, and the cycle just described is repeated during every revolution. The course of events during the expulsion of the products of combustion and the taking in of a fresh charge is shown in Fig. 1, by the prints a, b, c. The exhaust begins at a and the compression at c. Water is sprayed against the escaping gases for the purpose of cooling them, as may be seen in section c-d on the inset. As the pistons serve as valves for the various ports, any valve gear on the working cylinder is superfluous.

Regulation is accomplished by returning a part



AN OLD STREET RESERVOIR IN EAST BOSTON, MASS., UNCOVERED IN EXCAVATING APPROACH TO EAST BOSTON TUNNEL.

of the mixture, in case the speed rises, from the pressure pipe to the suction pipe of the feed pump. For this purpose the governor is arranged to control a by-pass valve in a pipe leading from the pressure side to the suction side of the feed pump.

This engine was applied to the driving of an alternator at Hoerde, Germany, by the Hoerde Bergwerks-und Huttenverein, who have the credit of being the first firm in Germany to use blast-furnace gas in a gas engine.

The cylinder of this engine is 18.9 ins. in diameter, the stroke is 31.5 ins., and the speed is 135 revolutions per minute. A single cylinder delivers 300 HP. The 600-HP. engine consists, therefore, of two such working cylinders, between which is mounted the armature of the dynamo, serving as a

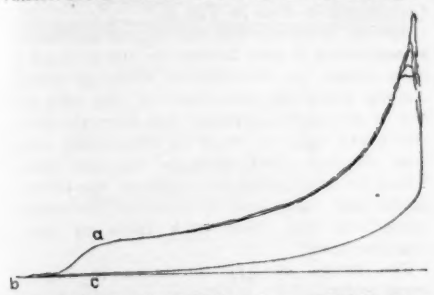


Fig. 1.—Indicator Card Taken from 600-HP. Two-Stroke Cycle Gas Engine.

flywheel. The Hoerde Co. reports that the gas consumption at full load is 124 cu. ft. per HP.-hr., the gas containing 100 to 112 B. T. U. per cu. ft. The compression reaches 124 lbs., and the highest pressure of explosion is 355 lbs. per sq. in.

A later type of the Oechelhauser engine has been constructed by the Aschersleben Machine Co. It is shown by Fig. 2, from which may be seen the peculiar construction of the cylinder. The connecting rod is attached directly to the forward piston. The scavenging air is furnished by the engine itself, only the rear end of the feed pump being used to handle the explosive mixture, while the forward end furnishes air at a pressure of 5 lbs. per sq. in. to the scavenging ports. Small variations in speed are taken care of by a variation of the quality of gas in the charge, larger variations by a change in the quantity taken in. The governor is arranged to regulate the gas mixture valve, as well as the return valve. In order to prevent the possibility of the unburned mixture escaping through the exhaust passages, the parts are so proportioned that the charge corresponding to the greatest power of the engine fills only 0.7 of the volume of the cylinder.

The firm of Korting Bros. is also building a 500-HP. gas engine which in its design is based upon the experience with the two-stroke machines described above. It will be so arranged that each piston will be double-acting, thus giving an impulse at every stroke, as in the steam engine.

The two-stroke machines are due to an effort to get smaller cylinder diminsions and greater uniformity of speed for the same powers than is possible in the four-stroke cycle type. While in the latter the working cylinder and the feed pump are in the same piece, inasmuch as the cylinder serves alternately as a working cylinder and a feed pump, in the two-stroke engine these functions are separated. In small motors this leads to complicated and costly machines, which cannot compete with four-stroke engines, and, hence, have long since disappeared from the market. However, the case is different with large machines, where, in order to secure smoothness of running we have often multiplied the cylinders, as in the steam engine. Here the experience with smaller motors cannot be used in judging the two-stroke cycle. But, while the working capacity of the cylinder is nearly double in the two-stroke machine as compared with the four-stroke machine, still we should not forget that another cylinder of equal capacity must be provided to handle the mixture and another to handle the scavenging air, making altogether more cylinder space than in a four-stroke machine of the same capacity. However, only one cylinder must be built to withstand the high pressures and temperatures that the working cylinder is subjected to, and, moreover, valves may be dispensed with on the latter, as we can at least allow the exhaust gases to escape through ports uncovered by the piston.

In the Oechelhauser machine one cylinder with a given diameter and piston speed delivers as much power as four four-stroke cycle cylinders, since two pistons work within it. It should be observed, however, that the cylinder is twice as long, and that two pistons, a three-cranked shaft and a rather complicated attachment for the rear piston are necessary, so that, finally, practical experience must decide which system is the simplest and cheapest.

So far as economy in gas in concerned, the two systems appear to be about equal in theory, since the processes are the same in each case. The two-stroke machine, however, has probably a greater loss in fluid friction, since there is not only the resistance in the suction pipe of the feed pump, but also that due to the quick transfer to the working cylinder. If the scavenging of the cylinder in the two-stroke machine is efficient in removing all products of combustion, while a portion remains in the compression space of the four-stroke machine, the former would have that much advantage. On the other hand, it is to be questioned if some of the fresh mixture does not escape through the exhaust ports before they are closed. It may be noted also that with the present abundance and cheapness of blast furnace gas, the matter of high economy is not so important after all as the matters of simplicity, cheapness and reliability in operation.

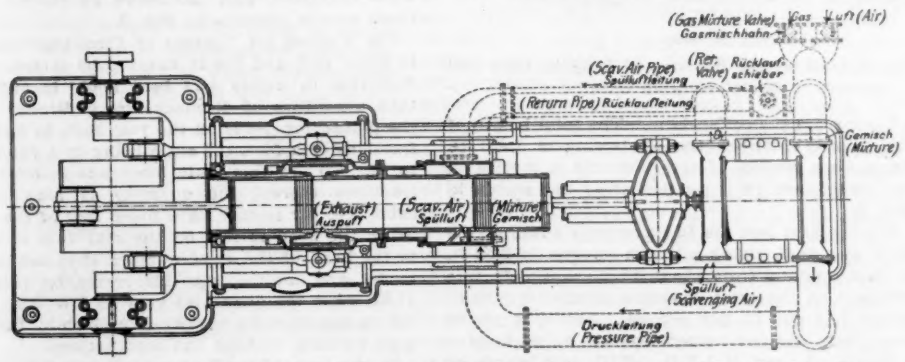


FIG. 2.—A TWO-STROKE CYCLE GAS ENGINE, Built by the Aschersleben Machine Co.

EXPERIMENTS ON THE FLOW OF WATER OVER DAMS.*

This investigation was undertaken after full consideration of that of the late Jas. B. Francis on a model of the Lawrence dam, and of those of H. Bazin, published in "Annales des Ponts et Chaussés," between 1888 and 1898. It was prompted by suggestion of a hydraulic engineer in charge of one of the largest water-power plants in New England. After the work was practically done, the very complete paper of Mr. Geo. W. Rafter, M. Am. Soc. C. E., in the "Proceedings" of the American Society of Civil Engineers for March, 1900, came to hand. It then appeared that these experiments are fairly supplementary also to those of Mr. Rafter, since three of the types are essentially different from any of his models, and two of these represent dams famous in the history of hydraulic engineering in the United States. The models used were carefully constructed to a scale of one-twelfth.

In 1852, Francis experimented with a model of the stone dam across the Merrimac River at Lawrence, Mass. An empirical formula was deduced by him which agrees within 1% of his experimental results between heads of 7 ins. and 20 ins. This formula is now used to measure the quantity of water flowing in the Merrimac River at Lawrence, and to determine the flow of water over dams of similar section at various places. Bazin and Rafter both assumed the general theoretical formula:

$$Q = c\ l\ H^{\frac{3}{2}},\dagger$$

in which $c = m\sqrt{2g}$, and determined the values of m for various heads upon several type forms.

The selected four sections are radically different from each other. It was thought that it might be possible to determine the best form of spill-way for reservoirs, or the best form of dam profile to use when small differences in the level of the back-water is a determining feature, and to measure approximately the quantity of water flowing over a dam of any of the sections chosen.

The water for the experiments was obtained through a 4-in. pipe connected directly to the mains of the town. A sharp crested weir, 21 ins. long, in brass plate with end contractions was used for the measurements of the water and was supplemented by a 1¼-in. fire nozzle and a nozzle connected to a 2-in. pipe for a check. The rating of the 1¼-in nozzle was done by weighing successively nearly equal quantities of water, pouring them into the measuring tank, which is of brick, cement-lined, holds about 90 cu. ft. and is water-tight. Sufficient hook-gage readings were taken so that a curve could be constructed with volumes denoted horizontally and hook-gage readings vertically. The curve thus constructed agreed exactly with like curves determined at several different times. With a pressure gage attached to the play-pipe of the nozzle, the water was allowed to waste until the pressure became constant. A diverting gate opposite the nozzle and swinging upon an axis at one end was then dropped quickly and a stop-watch, reading to one-fifth of a second, was started. When the water in the tank had reached a sufficient height the diverting gate was suddenly raised and the watch stopped. Meanwhile the pressure had been observed. A hook-gage reading was then taken. Thus, with the quantity of water read from the calibration curve for each particular hook-gage reading, the observed pressure and the time, there was plotted one point in a curve. Several different pressures were used and the points found above were plotted, through which was constructed a curve with quantities of water in cubic feet per second upon the horizontal scale and pressures upon the vertical scale. The nozzle on the 2-in. pipe was rated in practically the same way.

Several experiments were made in which pressures at both nozzles were noted and the quantities of water actually measured in the tank. The quantities read from the nozzle curve and the measured quantities checked within 1%. The great uniformity of these results together with an examination of the results of Freeman upon the flow of water through nozzles have led us to place equal weight upon quantities obtained in this way and by the weir.

Francis' weir formula for weirs with end contractions was used, namely,

$$Q = 3.33\ (b - .2\ H)\ H^{\frac{3}{2}}.$$

and found to agree very closely with this brass weir with results by direct measurement by different observers, and also to agree more nearly with the nozzle experiments than the fomula,

$$Q = c^{\frac{3}{2}}\sqrt{2g}\ b\ H^{\frac{3}{2}},$$

in which the values of c were substituted from a table given by Merriman as deduced from experiments made by Lesbros, Francis, Fteley and Stearns and others.

*Abstract of a graduation thesis by A. H. Greenwood, L. S. Oakes, and J. L. Sanborn, jointly, at the Thayer School of Civil Engineering. Experiments made during three months, January to April, 1900.

†See Francis' "Lowell Hydraulic Experiments."

The Lawrence Section.—A model of the masonry dam at Lawrence was first experimented with. This dam was built by Charles S. Storrow for the Essex Co. of Lawrence, Mass., between the years 1845 and 1848. Its length, including wing walls, is 1,629 ft. The length of overfall is about 900 ft. The dam is curved up stream slightly, the middle ordinate being 14.98 ft. This dam remains a monument to the designer, who clearly saw and correctly estimated in the beginning and continualy kept in view the magnitude of the unprecedented construction. An outline section of the dam and a section of the model used in the experiments is shown by Fig. 1.

The model was constructed to a scale of 1 in.

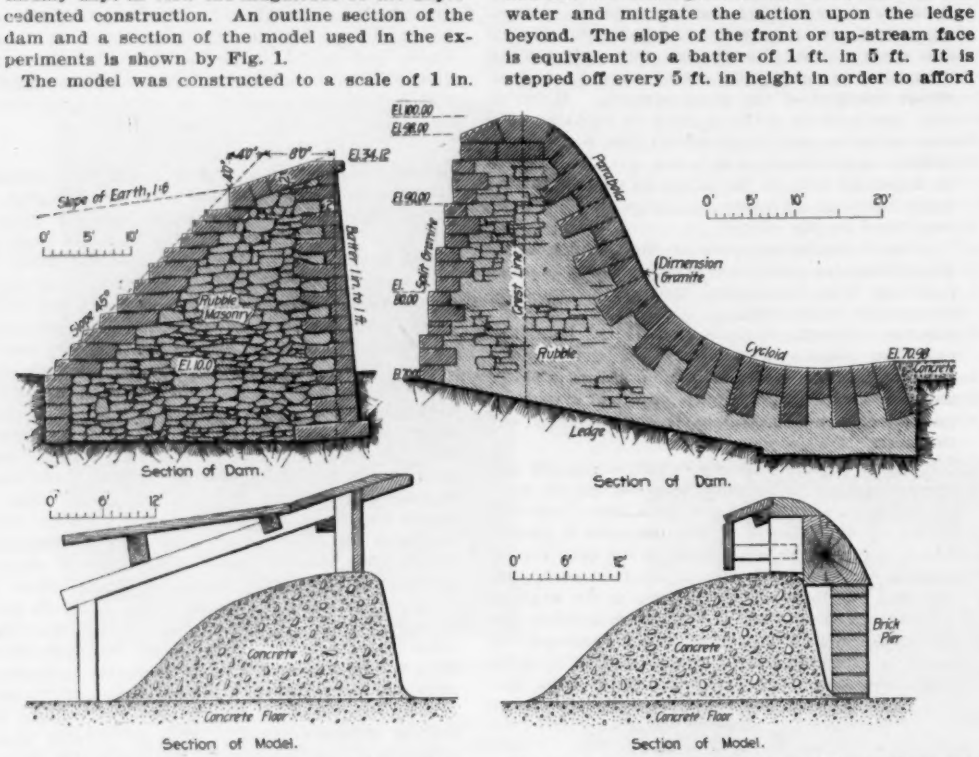


Fig. 1.—Transverse Sections of Lawrence Dam, and Model of Lawrence Dam.

Fig. 2.—Transverse Sections of Holyoke Dam and Model Holyoke Dam.

to the foot and was set in a lower tank, which receives directly the discharge from the measuring tank over the standard weir. All joints were made water-tight. The model was then painted and as smooth a surface as possible was obtained. Stilling-racks were placed in both tanks, and accomplished their object to a satisfactory degree.

During the experiments one man was stationed at the pressure gages and kept the record. One man was stationed at each hook-gage, and these men exchanged places after each reading. Thus, two men read each of the hook-gages at each height and a check was obtained. About 1.15 cu. ft. of water per second could be obtained. The full width of the tank, allowing for side pieces, 2.8325 ft., was used for the length of the crest for heads from 0 to 0.26 ft. The side pieces were then brought nearer together, 1.515 ft., and a head of about 0.39 ft. was obtained on the dam. Any desirable head below these limits was obtained by throttling the nozzle.

The tables giving the results of 58 experiments show that the differences between the quantities by nozzle and by weir do not in any case exceed 3% of the quantity as measured by the weir. These two quantities were then averaged and a curve plotted showing the heads in inches upon the vertical scale and the quantities of water in cubic feet per second for a section 1 ft. in length upon the horizontal scale. The pressure gages were tested by means of a Crosby gage tester. The experiments were performed after 9 p. m., when the pressure in the street mains had become nearly constant. The velocity of approach was not considered, as the area of the tank section was from 8½ to 10½ times the area of the discharge section.

The Holyoke Section, New Stone Dam.—The water power at Holyoke is by far the largest in New England, and is one of the largest developed powers in the United States. The average total head is about 60 ft.

The upper part of the curve of the down-stream face of the dam is a parabola, the parabola selected being the theoretical form assumed by a body of water flowing freely 4 ft. in depth over the crest of a dam. The parabola extends down the slope as far as the point of reversal, and below this the curve is a cycloid, selected as the curve of quickest descent. The up curve at the extreme toe is designed to break the force of the water and mitigate the action upon the ledge beyond. The slope of the front or up-stream face is equivalent to a batter of 1 ft. in 5 ft. It is stepped off every 5 ft. in height in order to afford a footing for the coffer dams. The total length of the rollway between the abutments is 1,020 ft. An outline section of the dam and a section of the model used in the experiments are shown in Fig. 2.

For the first test the full available width of the tank was used, giving a length of crest of 2.62 ft. A head, varying from about 0.1 ft. to 0.25 ft. was obtained on the crest, giving a maximum flow of about 1.14 cu. ft. per second. The side pieces were then brought nearer together so as to give a length of crest of 1.3 ft. With this length of crest, heads varying from 0.24 ft. to 0.41 ft. were

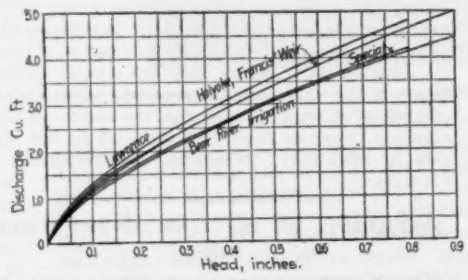


Fig. 3.—Diagram Showing Curves of Discharge Over Dams, With Four Forms of Crests Compared With Discharge Calculated by Francis' Weir Formula.

obtained, the maximum discharge being as before, 1.14 cu. ft. per second. The curve of discharge for a section one foot in length is shown by Fig. 3.

The Bear River Irrigation Dam.—In deciding on a form of dam for the third set of experiments the Bear River Irrigation Dam was selected as having a distinctive section. This dam was built in 1889 to 1890 for the purpose of storing water to irrigate the plain of Bear River, located in northern Utah. The dam is 370 ft. long and of a maximum height of 17½ ft., maintaining nearly that height for the entire length. Fig. 4 shows a cross-section of this dam. It is a crib dam of heavy timbers, with spaces filled with stone, faces heavily planked. The slope on the face on down-stream side, is ½ to 1, and 2 to 1 on the up-stream side. In Fig. 4 there is also shown a section of the model used.

The length of the crest used for the first set was 2.62 ft. With this length of crest the flow on the dam varied from about 0.09 ft. for a flow of 0.3 cu. ft. per second to 0.23 ft. for a flow of 1.13 cu. ft. per second. With the side pieces placed so as to give a length of crest of 1.73 ft. heads varying from 0.25 ft. to 0.36 ft. were obtained. The curve of discharge plotted from the results is seen in Fig. 3.

Special Section.—For the fourth and last set of experiments it was decided to try a model of the dam across the Connecticut River at Wilder, Vt. Among other changes made on this dam perhaps one of the most important has been the change of the sharp angular crest to a rounded crest. It was thought that because of this change it would be interesting to round off the crest of the model last used, and to compare the results obtained by this crest with those of the sharp angular crest.

The model adopted is shown in Fig. 5; the crest is formed by a circular arc with a radius of 1½ ins. With the crest thus rounded it was found that the usual free passage of air did not occur under the nappe, except under high heads, and that the water clung closely to the face of the model.

For the first test the length of crest was 2.58 ft., and the heads on the crest varied from 0.1 ft. to 0.23 ft. In this test the air could not get under the stream. In the second test the length of crest used was 1.44 ft., and the heads varied from 0.25 to 0.35 ft. In this test the heads were such as to allow an air filled space under the nappe. The full results of the test of this model were tabulated, and the curve as plotted from these results appears in Fig. 3.

Fig. 3 gives the "Curves of Discharge" plotted to cubic feet and heads varying by inches. The reduction to inches was here made in order to take quantities of discharge more directly from the plates, for heads on the real dam, in feet and fractions of a foot, the scale being in a ratio of 1 to 12. To use this plate for heads in feet or in fractions thereof the quantity is read off in cubic feet per second for a lineal foot of the dam, using the head in feet on the real dam as equal to the head of the same number of inches on the model and multiplying this result by $(12)^{\frac{3}{2}}$ or 41.57, since the quantities vary as $H^{\frac{3}{2}}$. Also plotted on this diagram is the curve given by Francis' weir formula without end contractions.

In the case of the Lawrence dam an air space was at all times under the nappe, the dam being so constructed that this could not be prevented. In all of the other experiments there was a depressed and adhering nappe, with five exceptions for the special dam.

As to the accuracy of the results, it is certain that every possible care was taken, but the small scale of operations must without doubt lead to a discrepancy in direct comparisons. The difference of flow between the weir or nozzle results and the mean flow, used in computations, has a maximum error of 1.2%, with an average error of less than 0.5%.

Having plotted the curve of discharge for the Lawrence dam, Fig. 3, it was desired to construct a formula for the curve. Francis' formula for the Lawrence dam,

$$Q = 3.01208\ L\ H^{1.52},$$

shows a discrepancy varying from 0 to 6.5%. In all cases except the first the Francis' formula gives a too small quantity, and in the first it is a few ten thousandths greater. The variations from this formula which gave us the best results was

$$Q = 3.01208\ L\ H^{1.5}.$$

Here there was an equal error on both sides of the curve up to about 3%. After having found that no single simple formula could be made to conform to this curve for the Lawrence dam, careful attention was given to the recent paper by Mr. Geo. W. Rafter in the "Proceedings of the American

Society of Civil Engineers" for March, 1900, on the "Flow of Water Over Dams," which at this time had just come to hand. It was evident that a formula without varying quantities would give too much discrepancy. Not having at hand a corps of computers, it was decided that the curves plotted from results as to the various observed quantities of water discharged would prove more accurate in actual use than a formula having coefficients varying as the heads.

As to the results from the model of the Holyoke dam, it appeared, after having plotted the

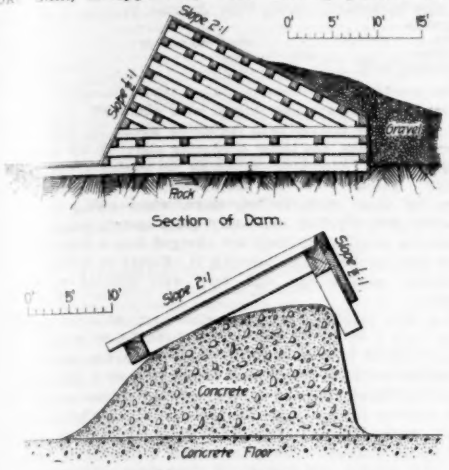


Fig. 4.—Transverse Sections of Bear River Dam and Model of Bear River Dam.

curve, that it coincided with the curve given by Francis' weir formula without end contractions with the exception of the lower heads; here the quantity of discharge for equal heads gives a trifle greater amount by Francis' formula than obtained by our experiments. This may be seen by reference to Fig. 3. Thus for high heads the Francis' weir formula without end contractions is a fairly satisfactory formula according to the results.

The Bear River Irrigation Dam gives, as shown by Fig. 3, the greatest discharge of water for equal heads of any of the dams experimented with. In this case no attempt was made to es-

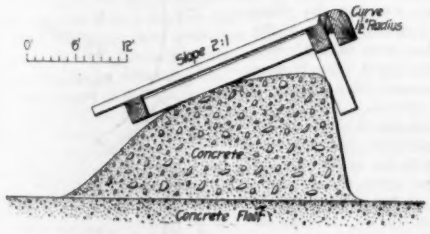


Fig. 5.—Transverse Section of Special Model Dam.

tablish a formula for the curve of discharge, but a direct comparison was made with one of Bazin's forms, numbered 162, which was also experimented with by Mr. Rafter in his set of experiments conducted at Cornell University. This form has the same slope on its up-stream face, but its overfall has a less slope, being 1 to 1 as against ½ to 1. Omitting this difference, we find that the results vary from 1% to 6½%, with an average variation of about 3% from those of Mr. Rafter.

The last set of experiments was with the form known as the Special dam, with results shown by Fig. 3. There is a decrease in the amount of discharge for equal heights from those of the Irrigation Dam. This decrease in discharge varies up to about 9% from 0% for the very small heads.

Without attempting to make any very direct comparisons with the experiments of others, we may be warranted in making two definite conclusions, viz.:

(1) That the Lawrence section, and especially the Holyoke profile, do not compare favorably with the sharp crested Irrigation dam.

(2) That a sharp crested dam with a good approach gives a greater flow of water with a given head than one with a rounded crest, joining exterior and interior slopes which are nearly at right angles.

To be more specific as to the comparative discharges, it will be noted on the diagram of discharge-curves that with a head of 4 ins. in both cases the discharge of the Irrigation dam was more than 25% greater than that of the Lawrence form. This is equally true for heads of 3 ins. and 2 ins. For a 1-in. head the increase of discharge is more than one-third.

The number of carefully checked experiments by which these results were deduced in the four cases were respectively 19, 14, 13, 12, making a total of 58.

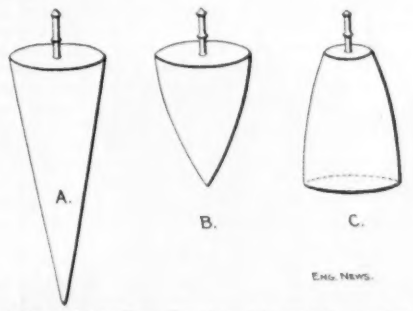
A NOVEL FRENCH METHOD OF MAKING FOUNDATIONS IN SOFT GROUND.

In constructing the foundations for some ten or more of the Exposition buildings at Paris the engineers made use of a method of compacting the soil by a machine similar to a pile-driver, and the process possesses so much internal evidence of merit and has been apparently so successful in actual operation that we have taken pains to collect such information regarding it as is conveniently available. The apparatus employed and the system of construction itself are the invention of Messrs. Dulac and Ducloux, of the firm of Dulac, Ducloux & Minuet, of 5 Rue de Laborde, Paris, France, from whom we have secured the information from which the following brief description has been prepared. Altogether, according to a recent published statement made by this firm, the new method of foundation construction has been employed for about 30 large buildings, among which are electric power houses, a waterworks reservoir, and several manufacturing plants, besides the Exposition buildings previously mentioned. In all these cases, according to the same authority, the construction has proved perfectly successful in very difficult soils, and much cheaper than any of the more common methods previously employed in performing foundation work in similar material.

Described in the fewest words, the new method of construction consists in inserting in the soft soil at more or less close intervals masses of hard material by which it is compacted until it will sustain the desired load. The masses of hard material, which may be concrete, furnace clinkers, gravel, etc., are inserted without excavation by means of a device designed for this special purpose. This device consists essentially of the three castings shown in the accompanying sketch and of an ordinary pile-driver frame, by which the castings are raised and let fall like a pile-hammer. The castings A and B, shown in the sketch, are employed for making the perforations into which the concrete or other hard material is placed, and the casting C is employed in testing the resistance of the soil and for compacting the material with which the holes perforated by castings A and B are filled. The actual weights of the respective castings are as follows: Casting A, 1,500 kgs. (3,300 lbs.); castings B and C, 1,000 kgs. (2,200 lbs.) each.

In beginning a piece of soft ground foundation work by this method, the first proceeding is to test the resistance of the soil by means of the casting C. This casting is raised by means of the pile-driver rigging a known height, usually 10 m. (32.8 ft.) and let fall upon the ground and the depth of penetration is measured. This depth is obviously inversely proportioned to the resistance of the soil; thus a soil which permits a penetration of 1 m. has a resistance of 10,000 kgs., while one which permits a penetration of 0.1 m. has a resistance of 100,000 kgs. The area of the striking face of the casting being 0.3 sq. m., the resistance per square centimeter in the two cases assumed is, respectively, 10,000 ÷ 3 = 3.333 kgs., and 100,000 ÷ 3 = 33.333 kgs. To allow for losses only 50% of these amounts, or 1½ kgs. and 15 kgs., respectively, are assumed in actual practice. Knowing the unit load to be used upon the foundation bed, the amount of resistance which must be added to the soil by the method of consolidation just described is determined by subtracting from this unit load the unit resistance determined by means of the casting C.

In soils, whose unit resistance determined as described is from 1 kg. to 3 kgs. per square centimeter after subtracting the factor of safety of 50%, the holes are formed by means of the casting B and are usually made from 1½ to 2 m. (4.92 to 6.56 ft.) deep. Between the successive falls of this weight the concrete, sand, clinker or other hard material is shoveled into the hole so that the falling weight compacts the filling and forces it into the soft surrounding soil. This work is continued until it is judged that the resistance at this point has reached the required amount, which is finally determined by a test, using the casting C. The apparatus is then removed and another hole sunk



Sketches of Castings Employed in Sinking and Compacting Pillars or Piles of Hard Material in Soft Ground Foundation Work.

Dulac, Ducloux & Minuet, 5 Rue de Laborde, Paris, France, Inventors.

and tested, this operation being repeated until the whole foundation area has been compacted.

When the depth and softness of the soil require the process of consolidation to be carried to a much greater depth than is indicated above, the mode of operation is first to sink a hole by means of the casting A. The inventors of the system mention cases where holes have been sunk in this manner to depths of 8 and 10 m. (26.24 to 32.8 ft.) in very soft soils without the sides of the hole caving in, the explanation being that the lateral compression of the soil is always great enough to keep the walls of the hole stable for some time. When the hole is sunk, casting B is substituted for casting A, and the hard material is shoveled into the hole and compacted, just as described above for the shallower foundation. The final test is made by the casting C. The greatest diameter of casting A is about 0.7 m. (2.29 ft.).

The lateral penetration of the hard filling into the soft soil surrounding the hole is a matter to which particular attention is called by the inventors of this method of construction. It is stated that it a common thing to use a volume of hard material equal to five times the volume of the original hole. Several of the foundations for the Exposition buildings were sunk by the method to a depth of from 5 m. to 8 m. (16.4 to 26.24 ft.) below the water level of the River Seine. It is stated also that the method has been successfully employed in quicksand and silt.

It will doubtless be appreciated that such a system as this would naturally be developed in a country where timber is scarce and expensive and where the use of wooden piling in foundations, so common in the United States, means a largely increased outlay. It appears probable, however, that where firm strata are located at a moderate depth the method of making foundations above described would be both cheaper and better than the use of wooden piling, even under American conditions, and the subject is, therefore, well worth the attention of American engineers.

THE GAS TURBINE is the subject of a lengthy investigation by Mr. W. O. Amsler, published in the "Sibley Journal" for May. He concludes that a gas turbine would have all the disadvantages of a steam turbine and much lower thermal efficiency, and that there is, therefore, little object for inventors to undertake work in this field.

THE PRODUCTION OF PLATINUM in Russia has increased from 6,363 lbs. in 1890 to 13,242 lbs. in 1899. The Ural Mountains district furnishes 95% of the world's supply of this metal.

A COOLING TOWER OPERATING WITH NATURAL DRAFT.

We illustrate herewith a cooling tower recently brought out by the Wheeler Condenser & Engineering Co., of New York city. It is very similar to the Barnard tower, manufactured by the same firm, except that the outside casing is omitted and natural draft and the winds are depended on for air circulation.

The water is forced to the top of the tower through the uptake A to the trough B, from which

Fig. 1.—Barnard Fanless Water-Cooling Tower of 1,000-HP. Capacity.
Built by the Wheeler Condenser and Engineering Co., of New York city.

it is distributed by the radiating perforated tubes C onto galvanized iron wire matting, over which it trickles to the collecting tank at the bottom.

The towers are so designed as to be able to cool water from a temperature of 135° F. to 85° to 90° F. in the worst conditions of humidity, winds and temperature.

The tower shown in the half-tone cut is 30 ft. high, and is intended to keep cool the condensing water used by a 1,000-HP. engine.

In constructing the tower it has been sought to secure both lightness and rigidity, in order that it may be installed upon roofs or in other positions exposed to the wind. The distributing pipes are divided into sections from which the water may be shut off at will to facilitate cleaning and repairs. The top of the tower is surrounded by a platform D, enclosed by a railing.

For the foregoing details and the material used in preparing the illustrations we are indebted to Mr. B. F. Hart, Jr., of the above-mentioned company.

THE UTILIZATION OF BLAST-FURNACE SLAG FOR PORTLAND CEMENT MANUFACTURE.*

By Cecil von Schwarz.

Much has been written, suggested, and experimented on the important subject of utilizing blast-furnace slag. The gradual enlargement of blast-furnaces has also considerably increased the quantity of their product, not alone of pig iron, but also of their principal by-product, namely, slag. To dispose of the large quantities of blast-furnace slag turned out in a proper and economical way has caused a good deal of study, trouble, and, in some cases, even embarrassment, to our blast-furnace managers. The use of blast-furnace slag for sand bricks and cement, even the utilization of the heat stored up in the hot liquid slag, has been suggested, and in several cases has been carried out. But the fact that large quantities of blast-furnace slag still remain unusued serves to indicate the want of success of the methods hitherto employed for utilizing it.

A few isolated results were obtained some time ago with blast-furnace slag cement, giving rise to hopes that now the important question of utilizing blast-furnace slag in a proper and satisfactory way was solved; but it soon turned out that the slag cement was of a somewhat untrustworthy quality, and the consumers consequently abandoned it in most cases. Only quite recently a method has been employed to manufacture cement out of blast-furnace slag which has given everywhere the best results with reference to strength, voluminal constancy and reliability. This method has recently been employed in Germany and Belgium with great success, and is briefly as follows:

The slag is granulated by letting it run into a cast-iron trough, inclined to one in ten, where a strong current of cold water flows. The granulating of the slag has a considerable advantage with reference to its use for cement-making, as it turns it at once into small sand of a very brittle nature, thus preparing it in a high degree for the necessary pulverizing process coming hereafter. Besides this, the slag experiences by granulating chemical changes also favorable to the same purpose, the principal of these being the decomposition of the sulphide of calcium contained in the slag, as the latter is very injurious to cement. The calcium combines with the oxygen of the water to form lime (CaO), whilst the sulphur forms with the hydrogen of the water sulphuretted hydrogen gas (H_2S); thus: $CaS + H_2O = CaO + H_2S$.

The slag sand is removed by a perforated bucket lift and transported by means of a short wire-rope tramway to the drying stoves. These consist of long sheet iron drums slightly inclined, and angles riveted inside all along; the flame enters the drum on the lower part and leaves it on the other (higher) end. One such drum is capable of

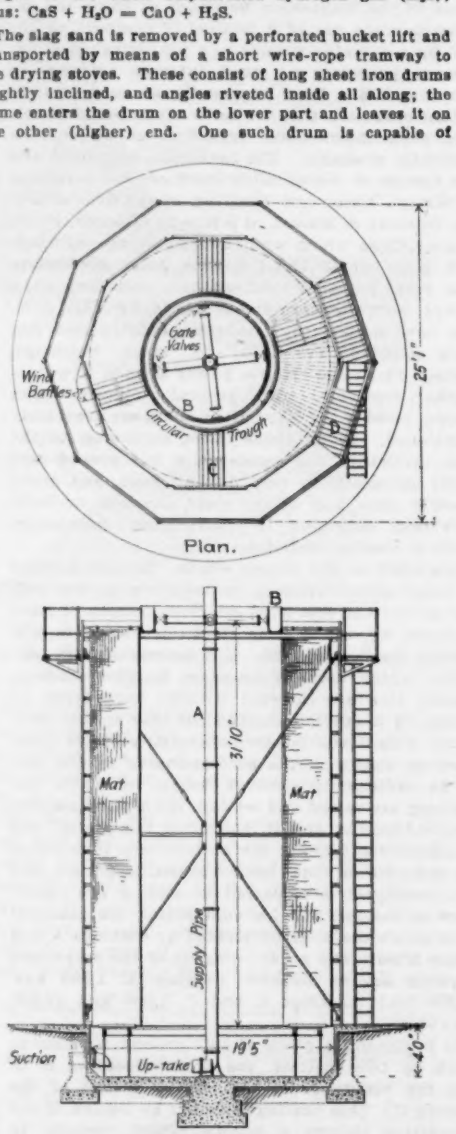


Fig. 2.—Plan and Sectional Elevation of Barnard Water-Cooling Tower.

thoroughly drying 30 tons of slag sand, containing about 25% of water, in 24 hrs.

The slag sand, thus dried, is now mixed about half and half with limestone of a good quality, broken up into pieces of about a fist in size. To this mixture about 3½% of powdered slacked lime is added, and the whole converted into powder of such fineness that not more than 2½% of residue remains on a sieve with 5,000 meshes per sq. in., and not more than 12½% on a sieve with 30,000 meshes per sq. in. As it is very important, for the cement to turn out a success, that a thorough mixture of the raw materials (namely, slag, limestone, and slacked lime) takes place, the fineness of the grain is controlled twice a day and any discrepancies remedied at once. The grinding into powder is effected by means of a cylindrical ball-mill for the coarse grit, followed by a so-called tube finishing-mill for the fine powder. One cylindrical ball-mill together with a tube finishing-mill produce about 60 tons of powdered raw material in about 24 hrs., and consume about 45 HP. both together.

The following is an analysis of the blast-furnace slag sand and of the limestone:

Slag Sand.*

	Per cent.
Silica	30 to 35
Lime	46 " 48
Alumina	10 " 14
Ferrous oxide	0.2 "
Magnesia	0.5 "
Sulphuric acid	0.2 "
Manganous oxide	3 "

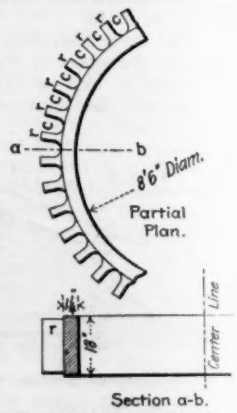
Limestone.

Calcium carbonate	90
Magnesia	0
Silica	0
Alumina	0
Sulphuric acid	0

The powdered raw material (slag sand, limestone, and hydrate of lime) are now mixed with about 8% of water and made into bricks, each weighing about 7½ lbs., by means of a press, the latter producing about 30,000 bricks in 24 hrs., and consuming, including the mixing apparatus, 16 HP. These bricks are stacked in the open and left there for about three to four days, when—owing to the presence of hydrate of lime—they get a certain amount of resistance, after which they are charged into a kiln to be burnt into clinker. The burning is effected in kilns of a particular construction and very well adapted to the purpose.

Each kiln consists, in its essential part, of a series of rings, each 1 in. to 1½ ins. in thickness, 8½ ft. inner diameter, and 18 ins. in height. These rings are provided outside with ribs, r, Fig. 1, and placed in such a way, one above the other, that the vertical ribs cover one another, thus forming little vertical channels (c, c, c,) all around, in which the air circulates from below to the top, like in a chimney, thus continually cooling the cast-iron rings from the outside, and preventing them from getting overheated. The materials to be burnt are in direct contact with the cast-iron rings, no lining of any kind being provided for. There are 18 such rings, put one above the other, the upper rings—where the greatest heat occurs—being hooped at the joints. The top of each kiln is provided with a cone and a chimney made of sheet iron, 3 ft. in diameter and 30 ft. in height. The cone has four charging-doors, which can be closed by sheet-iron covers as soon as the charging is done.

At a depth of 12 ft. from the top the inner diameter of the kiln is lessened to nearly half its inner horizontal section, and on this place provided with a double row of tuyeres to admit compressed air, this arrangement having for its object to burn any carbonic oxide or carburetted hydrogen gas arising from below as completely as possible, as well as to concentrate the heat exactly where it is required, viz., on the place where the formation of the clinker is to take place.



Part Section of Kiln for Burning Cement Clinker.

Compressed air is also introduced from below in two places. The compressed air is produced by a ventilator, the pressure being ¾-in. to 1¼ ins. of water. One charge consists of 100 bricks and 65 lbs. to 70 lbs. of coke as fuel; one-third of the coke could be replaced, if necessary, by anthracite or malgre piece coal.

As a rule, four kilns are arranged in one set, being provided with a common lift and a common platform, for all four kilns together. They are surrounded by a scaffolding made of angles and tees, on which the staircase to mount the platform is fixed. At the same time corrugated galvanized sheets are riveted on this scaffolding all round, in order to prevent unequal cooling of the furnaces outside in case of rain, wind, or snow.

The principal advantage of a kiln of this description is that, owing to the continuous and regular cooling from outside, the fritted clinker cannot clog the interior of the furnace, thus ensuring a regular and continuous working of the furnace. The ribs at the same time give strength, and prevent the cast-iron rings from warping. Each furnace produces about 25 tons of well-burnt clinker, equal to as much finished cement, in 24 hrs.

A little water is poured over the clinker after being drawn from below, in order to change any quicklime having formed itself, owing to imperfect grinding and mixing of the raw materials, into hydrate of lime, as well as to cool the clinker. The clinker is now stored in a covered shed for about six weeks' time, and then ground into fine powder by means of a cylindrical ball-mill, followed by a tube finishing-mill, viz., in the same way and under the same rules as described before with regard to

*Abstract of a paper read before the Iron and Steel Institute of Great Britain.

*This slag sand was produced from a blast-furnace turning out grey pig iron.

the grinding of the raw materials. The following is an analysis of the finished cement:

	Per cent.
Loss on ignition	5.70
Silica	23.70
Lime	59.08
Alumina	6.14
Ferric oxide	1.80
Magnesia	1.40
Sulphuric acid	1.30

This cement is distinguished by its exceptional high strength of compression and tensile strength, especially after a longer period of hardening. For instance, a mixture of one part of cement with three parts of sand showed:

After 28 days.

Tensile strength..... 282 to 370 lbs. per sq. in.
Strength of compression.....2,560 to 2,920 lbs. per sq. in.

After 360 days.

Tensile strength..... 538 to 700 lbs. per sq. in.
Strength of compression.....4,260 to 5,760 lbs. per sq. in.

As to the economic view of the question, the following figures may serve for information:

Prices of the raw materials.

(a) Blast-furnace slag sand..... 1s. 3d. per ton.
(b) Limestone..... 2s. 0d. "
(c) Coke..... 40s. 0d. "

All delivered free at the works.

(d) Cost of production per ton of cement at the works (including general expenses, depreciation, etc.).....18s. 0d. "
(e) Sale price per ton of cement.....32s. 0d. "

A slag cement factory provided with a set of four furnaces and other appliances to correspond produces from 25,000 tons to 30,000 tons of cement a year, and requires from 250 to 300 HP. to work it.

The above figures, analyses, etc., are taken from a cement factory which has successfully employed the above-described method for the last three years. The quality of the cement is so much valued that they have already sold this year's and the half of next year's production in advance.

Discussion.

Mr. W. E. Buesche (Brussels): The principal advantage of the process referred to results from the fact that a real "Portland cement," and not a so-called "slag cement," is obtained by the new invention. The excellent qualities of this Portland cement are principally due to the very high hydraulic qualities of granulated blast-furnace slag. In addition to this, the new process offers to the manufacturer the most important advantages with reference to the consumption of fuel and labor, these two items being from 30 to 40% less if Portland cement is made of blast-furnace slag (as described), as compared with any of the other methods hitherto in use for the manufacture of Portland cement. This considerable saving of from 30 to 40% in the cost of production may easily be understood from the fact that the granulated blast-furnace slag, having already passed through the high temperature of the blast-furnace, cannot undergo a new loss on ignition in the cement kiln, whilst the ordinary raw materials used for cement-making, such as clay, limestone, etc., endure about 40% loss on ignition in the cement kiln. Besides these great advantages offered to the manufacturer, others of still higher importance will be insured to the proprietors of the blast-furnaces, namely: (1) The whole working power required by such a cement factory may be supplied by engines worked with blast-furnace gases. (2) No more valuable space is taken away for the cinder-tips. (3) Even the old cinder-tips may conveniently be utilized for the erection of cement works.

To sum up, this invention is of the greatest economic value, as it creates new value out of waste materials hitherto quite worthless, thus strengthening the iron-works in their struggle against foreign competition, which gets more and more difficult every day. Of importance is also the fact that with this invention a great many different kinds of blast-furnace slag, not at all fit for the manufacture of "slag cement," can be utilized by the new process. All kinds of basic blast-furnace slag may be employed in manufacturing "Portland cement" by the new process.

Mr. Charles Wood (Middlesbrough): It has been known for some years that a good cement has been made from blast-furnace slag in Germany and Belgium, but whether this cement is equal to the tests exacted by English engineers it is difficult to say; but the chief point in its favor is that for ordinary purposes there is not much difference, and second (which goes a long way) is that it is sold in this country at a cheaper rate. This points to one of two things, viz., either the English cement-makers must be making a large profit, or else the Germans must have very cheap labor and be content with less remuneration.

We will just see how the process of manufacture compares with slag cement made at Skinningrove and Portland cement as carried out in this country. I understand from the paper the German system to be as follows:

(1) The slag sand is calcined or burnt in a Ransome's rotary cylinder, in order to drive off all the water held in a spongy cellular slag sand, and the small amount which may have combined with the sulphur and lime.

(2) This calcined slag sand is now mixed with about half-and-half of raw limestone, which has to be broken up into small pieces (which certainly costs something). This mixture is put into a ball-mill and ground to a fineness of 30,000 meshes to the inch, to which is added about 3½% of slaked lime.

(3) This material is now made into bricks, which have to be stacked and kept to harden.

(4) These bricks are now burned into clinker in a specially constructed furnace or kiln.

(5) The clinker, after it is drawn from the kilns, is watered and stored for six to eight weeks, and again ground into a very fine powder in a ball-mill; and

(6) Finished in a tubular mill.

Compare these six different operations with the simple way in which Portland cement is manufactured by the English makers, or with the way the manufacture of slag cement is carried out at Skinningrove blast-furnaces, which consisted simply of reducing the slag by blowing it into shot as it flows from the blast-furnaces, and then mixing it with fine powdered slaked lime and grinding it in the ball-mill to about the usual fineness of Portland cement.

The cost of the raw material is about the same in each case; if anything, in favor of the English houses. It would therefore seem absurd to suppose that the German mode of manufacture could be carried out here in England so as to allow a fair margin of profit.

It may be interesting here to compare the analysis of slag cement as given in the paper with English and also Portland cement:

Principal constituents.	German Slag Cement.	English Slag Cement.	Portland Cement.
Lime	59.00	46.00	60.00
Alumina, etc..	8.00	20.00	9.00
Ferric oxide, silica	23.70	25.00	22.00

The remarkable difference in these three analyses would naturally call for the remark that the cements cannot be of the same value in use, but there is no very great practical difference. Some cements take up more water of crystallization than others, and this is more so when the percentage of oxides and alumina are in excess, and this may somewhat equalize the difference.

The remarkable hardening effect of oxides of iron in conjunction with lime, silica, and alumina is well exemplified in the Italian puzzolanas, where, as in the best qualities, the lime is actually as low as 8%, while the oxides of iron run up from 12 to 15%. This hardening effect of oxides of iron induced the writer to employ the dust from the ironstone heaps, or from the calcining kilns, or spent pyrites from the chemical works, in conjunction with slag sand, wet direct from furnaces, ground up together with slaked lime in order to make a strong liquid cement or mortar.

The following proportions were used:

	Per cent.
Slag sand	40
Slaked lime	30
Spent pyrites or calcined ironstone	30
	100

There is quite sufficient water held in suspension in the slag sand to make the cement or mortar wet enough without adding any more, and if this is mixed up with broken slag shingle, say about the size of walnuts, leaving all the small in, and put straight away into foundations or walls, being slightly rammed down in about 8 to 10-in. layers, it will form a splendid concrete, equal to good Portland cement concrete, at about one-third or one-fourth the cost.

I may say I have made thousands of cubic yards of this for machinery foundations and walls. The entire building of the Cleveland Slag Works was made of this material, which was only lately demolished in consequence of the dock extension at Middlebrough, and the contractor will give his account of the difficulty he had in removing the underground work.

From this it will be seen that any one within the reach of slag sand and ironstone has the means of making a cement for concrete or a mortar for walling or building at a cost of one-third or one-fourth of the ordinary methods; but it must be used immediately, as it sets so quickly.

It may be also mentioned that this cement or mortar is perfectly hydraulic. The chemical action of the lime, iron, and sulphur is so quick that if ground fairly fine it will become quite warm. The water taken up as water of crystallization by this mortar or cement is unusually large, and confirms my previous remarks on the subject.

At the Cleveland Slag Works the manufacture of Portland cement from slag was discontinued in consequence of the difficulty of reducing the slag to a fine powder, the sharp cutting nature of which destroyed any grinding mill employed in a few hours; and it was only through the invention of the pounding action of the ball-mill which has enabled slag to be reduced to the required fineness economically.

The remarkable prominence in which the author of the paper introduces his kiln for making clinker suggests to the writer of these notes that the title of the paper might have been changed somewhat to the following, "A New Kiln and the Utilization of Blast-Furnace Slag." This kiln certainly seems to have one or two points worth notice, however, viz., that inside a series of cast-iron rings, of which a sketch is given, a temperature is maintained equal to molten clinker, whilst the rings are kept sufficiently cool to prevent their warping or melting by air on the outside. I should be afraid that the wear and tear on these rings must be rather severe.

Messrs. J. C. Johnson & Co., of Gateshead and London, very large Portland cement-makers, say that the German system of making cement would be ruinous in this country, and that great improvements in the manufacture of Portland cement are now being carried out which will prove very economical. (Mr. Wood in his remarks has evidently confused the cement described by the author, which is a true Portland cement with the more common puzzolana or slag cement.—Ed.)

A DEVICE FOR SAMPLING PIG-IRON.*

By Porter W. Shimer, M. Am. Inst. M. E.†

The device here described has been found useful in sampling foundry-iron, and there is no reason why it should not be equally useful in sampling other metals which are not too hard to be drilled with a breast-drill. It consists, as shown in Figs. 1 and 2, of an ordinary plumber's gas T (without bead) of about ½-in. internal diameter, over the leg of which is snugly fitted a small tin cup, about 1¾ ins. deep, to catch the drillings which are made by use of a breast-drill with a ¼-in. twist bit, working through the arms of the T.

The forward arm of the T is filed down to a blunt edge, over which is stretched a short piece of rubber tubing projecting a little beyond the end. The bottom of the inside of the front arm of the T is filed down to a slope,

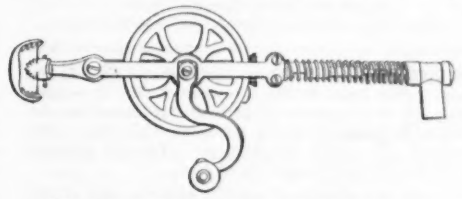


Fig. 1.—A Device for Sampling Pig-Iron.

to facilitate the passage of drillings into the tin cup. The rear arm of the T is fitted with a tin ring, projecting about ¼-in., for the purpose of holding in place a stiff spiral brass spring, which serves to press the sampler firmly against the metal to be drilled. The other end of the spring is supported against a shoulder of the breast-drill. The projecting rubber prevents the loss of any drillings, and also the falling of sand from above into the sampler. With ordinary care there need be no risk of getting particles of rubber into the sample.

It is, of course, not possible to get a fair average sample of drillings, representing a pile of foundry-iron, by taking drillings from any one or two pieces, because of the frequently mixed character of the iron. This observation applies more particularly to the sampling of iron as it is broken and piled at the foundry than to sampling at the

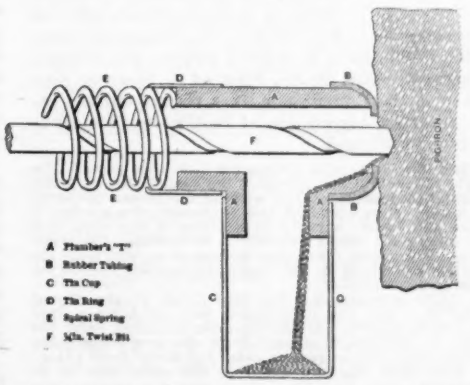


Fig. 2.—Section Through Tee of Pig-Iron Sampling Machine.

works, where, if the furnace is working regularly, a few pigs may fairly represent a whole cast.

By the use of this device, it is possible for a sampler to pass along a pile of pig-iron and take a little from each of ten or twenty or more pigs, by drilling a hole about ⅛-in. deep into each. A great advantage is that the drill-holes may be scattered all over the fractures, making one hole in each piece, but in a different part of each. In this way, inaccurate sampling, whether due to an insufficient number of pigs drilled or to any segregation in individual pieces, is readily avoided. It is necessary to brush off the fractures before drilling, to remove any adhering sand. It is also necessary to take as nearly as possible the same amount from each piece; otherwise the holes drilled into softer pieces will, very naturally, be deeper than those drilled into the harder pieces. When we remember that the softer pig-iron usually contains more silicon and less sulphur than the harder, the importance of this precaution is apparent.

*A paper read before the American Institute of Mining Engineers.
†Easton, Pa.

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The manner in which the Interstate Commerce law has been nullified by court decisions, and the powerlessness of the courts or the Interstate Commerce Commission to remedy abuses, was forcibly brought forward by Mr. Edward A. Moseley, Secretary to the Commission, in a recent address before the Hay Association at Baltimore. We quote from it as follows:

> When the Interstate Commerce law was passed, the people believed that authorizing the commission to forbid an unlawful charge carried with it the power to forbid the whole of such charge and to compel the carrier to "cease and desist" entirely from charging any other rate than such as it might find would be lawful. The commission acted upon that belief for ten years, and until the question was raised in the courts the carriers themselves acted upon that belief.
>
> In 1897, however, the Supreme Court of the United States said that the commission may condemn a rate which it finds to be unreasonable, but it cannot order the carrier to "cease and desist" from charging some other unreasonable rate, or even to cease and desist from charging more than the rate found in the same case to be reasonable.
>
> The rate on hay from St. Louis to Baltimore may be unreasonable, and in a case brought to test the question the commission may find it so, but if it does it can only forbid that particular rate. The carrier is at liberty to make only the slightest reduction and claim it has satisfied the law.
>
> Take a rate of 20 cts. on hay from St. Louis and assume the commission has found it to be unreasonable. The carrier need not obey that order until compelled to do so after four years' trial in the courts, and if required to obey it, the carrier need only reduce it say 1 ct. Now, assume that 10 cts. is a reasonable rate. It would require under that procedure 10 suits in the courts of the United States during a period of 40 years to secure the enforcement of a reasonable rate of 10 cts. on hay from St. Louis.

The issue laid down is a very plain one. Congress should either so amend the Interstate Commerce law as to give it the effect which its framers undoubtedly intended or it should repeal it entirely and abolish the commission. To leave things in their present condition is merely a huge absurdity.

Suppose a heavy freight train running at good speed is to be stopped by the application of brakes. If every car in the train could have at the same instant a retarding force applied to it exactly equal, in pounds per ton weight of the car, to the retarding force applied to every other car in the train, then the whole train would stop with perfect smoothness. No car in the train would tend to push against or draw away from its neighbors in front or behind, and there would be absolutely no strain put upon the couplings by the brake application. This ideal condition is never attained in practice. It is neither possible to apply the brakes with absolutely instantaneous effect, nor to exert on each car a retarding force just proportioned to its inertia. If the train had only two cars and the one in front were retarded with a force of 5,000 lbs., while the one behind were retarded with a force of only 3,000 lbs., evidently half the surplus pull of 2,000 lbs. on the front car will be transmitted through the coupling to the rear car.

Again, if the front car has 5,000 lbs. retarding force applied to it for one second before the brake is applied to the rear car, then during that second half the retarding force will be transmitted to the rear car and will cause a compressive stress of 2,500 lbs. in the coupling between them.

These figures will serve to illustrate the nature of the difficult problem which confronts American railway managers. They are operating longer and heavier trains year by year, hauled by locomotives which are all the time increasing in power. The speed of these trains are controlled by brakes which can exert a retarding force several times greater than the pulling power of the locomotives. For an illustration of the relative power of the two, comparison may be made of the distance which a locomotive must haul a train to bring it to full speed and the distance required by the brakes to bring it to a stop from the same speed.

Now this enormous retarding force, if applied unequally throughout the train, may be equivalent to the pull of a powerful locomotive, perhaps of more than one, upon the couplings joining the cars together. It is little wonder, therefore, that break-in-twos in train service are becoming more and more common.

Let us see what is required of the braking apparatus in order to obtain, not uniform retardation on all cars alike, which is an impossibility, but such an approach to it as is practically possible. The requirements may be enumerated as follows:

1. Quick application throughout the train. This is believed to be attained to as great an extent as is necessary by the present form of freight brake when in good condition and properly operated.

2. Uniform pressure in the brake-cylinders. To secure this, the triple-valves must be in good order so as to operate uniformly and the slack of the brake-rigging must be taken up so that the air will be expanded to the same degree in each cylinder.

3. Uniform pressure on the brake shoes. To obtain this, after a uniform pressure on the brake pistons is attained, it is necessary that the leverage of the foundation brake gear attached to the car bodies be uniform. Variations may be induced, even when the leverage is correct, by varying methods of applying the brake rigging to the car, varying elasticity, lost motion and friction in the parts of the brake rigging, etc.

4. A uniform coefficient of friction between the brake shoes and the car wheels. The importance of this matter is only beginning to be realized by railway officers. The valuable work of the Master Car Builders' Association in investigating the conditions of service of brake shoes has shown that a wide difference exists in the frictional resistance, wearing power and abrading effect upon the wheel of brake shoes of different materials. Recently a tendency has developed toward the introduction of brake shoes which wear much longer than the ordinary cast-iron shoe; but these are found to have, as a rule, a much lower coefficient of friction. Thus a car equipped with such shoes might have, for the same cylinder pressures, only two-thirds or less the retarding effect that a car would have equipped with ordinary shoes.

At the annual convention of the Master Car Builders' Association last June, it was voted that a committee of the Association prepare specifications for brake shoes which should provide limits of friction coefficients within which shoes would be accepted; in another column of this issue are reported some recent tests made at Purdue University bearing on this question.

Briefly stated, these tests show that brake shoe friction, like other cases of friction between lubricated surfaces, is a highly variable quantity. The coefficient varies with speed; it varies with pressure; it varies largely with the condition of the rubbing surfaces; but it does not vary with their temperature; at least at temperatures below 1,500°, and with such speeds and pressures as are ordinarily used in railway brake service.

Apropos of our remarks in this column last week concerning the possible restoration of the sailing vessel with auxiliary steam power to improve her as an ocean carrier, it is interesting to note that gasoline engines are already in extensive use as an auxiliary power for sailing vessels, especially on the Pacific coast. The New York "Commercial," in a recent issue, publishes an interview with the President of the Hercules Gas Engine Co., of San Francisco, in which it is estimated that a thousand sailing vessels registered at Pacific ports have been equipped with gasoline engines for auxiliary power. One great advantage from a commercial point of view is that no licensed engineer is required, and there is no Government inspection. In operation all fuel consumption ceases as soon as the engine stops, and there is no trouble with firing up and cooling down boilers, as is the case with auxiliary steam power. To offset these must be set the danger of carrying and handling gasoline. An oil engine, especially one which could use crude oil successfully, ought to be still more successful for marine service than a gasoline machine, and the saving in fuel cost on large size engines would be an important matter.

THE CONDITIONS OF MAXIMUM PUMPING ENGINE ECONOMY.

The recent tests of the Allis pumping engine at the Chestnut Hill Station of the Metropolitan Water-Works, Boston, and of the Nordberg pumping engine at Wildwood, Pa., both of which have been described in our columns,* have given such remarkable duty records that they are worthy of especial study.

Each engine has beaten all former records of engine performance, when measured by the only accurate method, the thermal unit basis, and each of them has given a larger return in work done for a given amount of heat furnished by the fuel than was ever before given by a steam engine.

The figures for duty are, per million B. T. U. in the steam furnished to the engine: Allis, 157,002,500; Nordberg, 162,948,824 foot-pounds. If, however, we take the Allis record on the basis of heat in the steam furnished by the boiler, considering the economizer as part of the engine plant instead of part of the boiler plant, the figure for the Allis engine is 163,925,300, which is a little higher than the Nordberg record. There is good reason for making use of the latter figure in comparing the two engines, for the Allis engine was designed with the idea of using the economizer, and not for heating its feed water with steam taken from the receivers of the engine, as is done in the Nordberg plant.

A most notable fact about the engines is that while they gave results so nearly alike, they are altogether different in design and proportions. The Allis is a triple-expansion engine, and the Nordberg a quadruple. The Allis runs at a speed of 17.2 revolutions per minute, and the Nordberg at 36.5. The Allis engine has one feed water heater using exhaust steam, but relies chiefly on an economizer to heat its feed water, while the Nordberg has five heaters, one supplied with the exhaust steam and the other four from the low pressure cylinder and the three receivers. The Allis engine expands its steam about 42 times and the Nordberg about 24.

Besides the records of these two tests, we have that of another Allis engine which has given a slightly higher figure per million B. T. U. in the steam furnished to the engine than the Chestnut Hill engine. It is the No. 10 engine of the St.

*A description of the Allis engine and the record of the test will be found in our issue of Aug. 23. The test record of the Nordberg engine was published in the issue of May 4, 1899, and an illustrated description in the issue of Aug. 23, 1900.

Principal Data of Pumping Engine Tests.

	Allis.		
Name of builder	Chestnut Hill.	St. Louis, No. 10.	Nordberg.
Location	Triple.	Triple.	Wildwood, Pa.
Kind of engine			Quadruple.
Cylinders, diameter in ins.	30, 56, 87	34, 62, 92	19½, 29½, 49½, 57½
" ratios of areas	1 : 3.48 : 8.41	1 : 3.32 : 7.32	1 : 2.26 : 6.68 : 9.00
" clearance, %	1.35, 0.55, 0.45	1.115, 0.46, 0.36	1.25, 0.55, 1.30, 0.36
" stroke, ins.	66	72	42
" jackcted	Barrels only.	Barrels only.	Barrels only.
Plungers, diameter, ins.	42	29½	14¾
Revolutions, per minute	17.5	16.43	36.5
Piston speed, feet per minute	192.5	197.16	256.0
Steam pressure in boiler, lbs.	187.37	130.2	199.87
Jacket pressures, lbs., gage	185, 73, 4.8	130, 52	200, 116, 40, 39
Receiver pressures, lbs., gage	30.85, — 3.31	26.6, — 3.2	85.5, 24.8, — 0.8
Receiver coil, pressures, lbs., gage	...., ...	130, 52	102, 104, 105
Vacuum, lbs. per sq. in.	13.8	14.04	13.11
Feed water temperatures to exhaust heater	....	.....	88°
" " " from exhaust heater	....	.....	104.9°
" " " from other heaters	....	.....	136°, 193°, 260°, 311°
" " " to economizer	79.7°	.....	.....
" " " to boiler	155.0°	80°	.....
Indicated horse-power	801.6	801.6	712
Friction of engine, %	6.71	3.16	6.12
Duty per million B. T. U.	157,002,500	158,077,324	162,948,824
Duty, including economizer	163,912,300	.....	.....
Dry steam per I. HP., per hour, lbs.	10.335	10.676	12.26
B. T. U. per I. HP., per min.	196.08, 187.8*	201.96	185.96
Thermal efficiency of engine, %	21.63, 22.58*	21.003	22.81
Number of expansions, about	42	23.4	24
Coal, per I. HP. per hour.†	1.062	.....	.....

*Including the economizer. †Including that used by fan, stoker, and economizer engines.

Louis water-works, which was tested on Feb. 26-27, 1900. An account of the test is given in a paper by Nils Johnson, read before the Engineers' Club of St. Louis, and published in the "Journal of the Association of Engineering Societies," for July. We give herewith a table containing the principal data of all three of these tests, so that they may be conveniently compared and studied.

The duty record of the St. Louis engine, 158,077,324 per million B. T. U., is, we believe, the highest figure ever obtained from a triple expansion engine, and it is especially noteworthy on account of the low pressure of steam used. The figure would not be as high as that of the Chestnut Hill engine, but for the remarkably low friction of the engine, only 3.16%, as compared with 6.71; and the thermal efficiency is 3% lower than that of the Chestnut Hill engine.

As is nearly always the case when records of different pumping engines are compared, it is not easy to trace any relation between the results obtained and the design and proportions of the engine and the conditions under which it is run. If any one were given the record of the Chestnut Hill engine, and asked to predict what record would be given by an engine of the same horse-power and the same speed, but with the steam pressure only 130 instead of 190 lbs., and the expansions only 23 instead of 42, he would probably name a figure much lower than the one obtained by the first engine; but here is the St. Louis engine, under these apparently unfavorable conditions, giving a higher duty record by nearly 1%, and a thermal efficiency only 3% lower. Is the increased efficiency which should be obtained by the higher pressure of steam in the Chestnut Hill engine partly neutralized by too high a ratio of expansion?

If the low friction of the St. Louis engine had been obtained at Chestnut Hill, the latter would have given a duty of 162,400,000, almost equal to the Nordberg engine record, in B. T. U. in steam used by the engine, or with the economizer it would have given 169,450,000, beating the Nordberg engine nearly 4%.

It looks as if the duty of the Chestnut Hill engine would have been higher if it had used feed water heaters in addition to its economizer, and as if the duty of the Nordberg engine could be improved by doing without some of its heaters and using an economizer instead. The Allis engine used an economizer to heat the feed water from 79.7 to 155°. It might have an exhaust heater and a heater taking some steam from the first receiver or from the high pressure jacket, so as to heat the water to over 200° to advantage. The Nordberg engine robbed its low pressure cylinder and its third receiver of steam in order to heat the feed water from 105 to 193°. This heating might be done with the waste heat of the gases from the boiler. There are many other questions suggested by these tests which can only be answered after still other engines are built and tested. For instance, (1) is the high economy of the Nordberg engine due to its quadruple expansion, or did the engine give its high record entirely on account of the system of feed water heating, and in spite of the four-stage expansion? (2) What is the use of building long stroke engines to run less than 200 ft. per minute piston speed, when shorter stroke engines can be built to run over 250 ft. per minute, without additional loss by pump friction, and at greatly less cost?

We have by no means yet reached the limit of pumping engine economy. The figures above given are remarkable in the light of older practice, but there is still room for progress, and there is still a lack of knowledge as to the design, proportions and condition of operation, which will give the highest economy.

The record of 1.062 lbs. coal per I. HP. per hour, made by the Allis engine with its boiler and economizer plant, is, we believe, the lowest figure yet obtained by any steam engine. It is nearly down to the best gas-engine practice with gas producers using anthracite coal or coke, and lower than any figure we have ever seen for gas-engines using gas from bituminous coal. We have no doubt that the figure can be reduced to 1 lb. of coal per I. HP. per hour with the Allis Chestnut Hill engine as it stands. We note in the record of the test three conditions outside of the engine itself which might have been changed with the result of lowering the record. They are: (1) The coal. This was Loyalhanna coal of a reported heating value of 14,023 B. T. U. per lb. It contained 4.85% ash. Allowing it to have 1.15% moisture the heating value per lb. combustible would be 14,918 B. T. U. This is about 900 B. T. U. (or 6%) lower than good Pocahontas or New River coal. It would appear that the figure 1.062 might be reduced to 1.00 by simply changing the coal.

(2) The inefficiency of the economizer. The economizer cooled the gases 263.5°, or from 485.4° to 221.9°, and heated the feed water from 79.72° to 154.98°, adding 75.5 B. T. U. per lb. Taking 20 lbs. gas per lb. coal burned in the boiler, and 9.8 lbs. water evaporated in the boiler per lb. coal, we have:

Heat used by the economizer per lb. of coal burned, 20 × 263 × 0.24 (specific heat)	1,262 B.T.U.
Heat transferred to the water, 75.5 × 9.8	750
Loss due to radiation, air leaks, etc. in the economizer	512 B.T.U.

This is about 40% of the heat given to the economizer, not including the necessary loss of the heat in the gases at 221° discharged into the chimney, and 3.6% of the heating value of the fuel.

(3) The loss of heat during the test due to cooling the drips from the separator, low pressure jacket, and receiver, for the purpose of weighing. This cooling caused a loss of heat which we estimate as follows:

	B. T. U.
Water from separator 2,019 × (354.64 — 28.93) =	657,608
From l. p. jacket, 25,886.5 × 173.77 — 50.84 =	3,182,227
From 2d receiver, 5,276 × (166.15 — 58.38) =	568,595
Total	4,408,430

This is practically 2% of the whole heat used by the engine, and this might be saved by pumping the hot drips directly to the boiler. It is quite possible by making the three changes we have suggested to bring the coal consumption from 1.06 down to 0.96-lb. per I. HP. per hour.

A still further reduction may be made by high superheating of the steam, which is now becoming quite common in Europe, but which American engine builders seem rather slow to adopt. With this improvement added, the fuel consumption of the plant may be brought down to, say, 0.90-lb. per I. HP. per hour and the duty raised to about 190 millions. All this is without any change in the engine itself. It is not improbable, however, that the proportions or design of either the Allis or the Nordberg engine might be changed with advantage. There is a great difference between a triple expansion engine expanding 42 times, and a quadruple engine expanding only 24 times; and it is quite possible that a triple expanding 36 times and a quadruple expanding 42 times would each give a better record than the present engines. The question whether a quadruple expansion engine is more economical than a triple expansion using the same steam pressure and the same number of expansions is still unsettled, and the tests of the Allis and the Nordberg engines throw no light upon the subject.

So much for the possibilities in the direction of still higher attainments in fuel economy of steam engines. The practical question in most cases where a large pumping engine is to be installed is not how great fuel economy can we reach, but how economical an engine will it pay to install. As has been pointed out before in these columns, the engine most economical in fuel may be by no means the most economical machine when the total expense of pumping is computed. Each case must be considered by itself, and in order to determine the most economical engine to install in a given place, the first cost of engines and boilers, the number of hours per year during which the engines are run, the rate of interest and depreciation, the cost of repairs, the cost of attendance, and the cost of fuel must all be taken into account.

In order to make clear the influence of these various items upon the ultimate cost, we have computed the accompanying table, in which valu s are assumed for the above-named variables. The most difficult item to estimate is the first cost of engines of varying economy. We have assumed, however, the cost of an engine of 50 millions duty at $30 per I. HP., and one of 100 millions duty at $60. Above 100 millions the total cost is assumed to increase at the rate of $1,000 (for an 800 HP. engine), per extra million of duty, this figure being the one awarded by the city of St. Louis to the E. P. Allis Co. as a premium for performance in excess of the duty guaranteed in the contract. It is probable that this figure is very much higher than the actual increased cost of construction necessary to obtain the increased duty, and that it allowed a handsome profit to the builders, but it will serve to illustrate the influence of prices on ultimate cost. The boiler and economizer capacity required to furnish the engine with steam is taken at 900 boiler HP. (34.5 lbs. per hour = 1 HP.) for the 50-million duty, 800-HP. engine, and proportionally less horse-power as the duty increases. The cost of boiler and economizer is taken at $30 per boiler HP. The fuel consumption is taken at 1 lb. of the best semi-bituminous coal per HP. hour for the 180 million duty engine decreasing as the duty increases. The cost for interest, repairs, depreciation, etc., is taken at 6% per annum for the engine, and 8% for the boiler and economizer. The labor cost is taken as follows:

Engine duty.								Cost per day.
50	Three	men	at	$3.00,	and 5	men	at $1.50 =	$16.50
100	"	"	"	4.00,	" 3	"	" 1.50 =	16.50
120	"	"	"	5.00,	" 3	"	" 2.00 =	21.00
150	"	"	"	6.00,	" 3	"	" 2.50 =	25.50
180	"	"	"	6.00,	" 4	"	" 2.50 =	28.00

Two assumptions are made of the time of running the engine, viz., 4,000 and 6,000 hours per year, and three assumptions as to the price of fuel, viz., $3, $4 and $5 per ton of 2,000 lbs.

The results given in the table show that at 4,000 hours per year of running, the 100 million duty engine is the one of lowest annual cost for all three of the assumed prices of fuel; and also for 6,000 hours a year when the fuel costs $3 per ton. The 120 million duty engine gives the lowest annual cost at $4 and $5 per ton, and 6,000 hours per year. The figures in the last column show that for 6,000 hours a year and $5 per ton the annual cost for all four engines, of 100 million duty and above, is very nearly the same. If the engines ran full time, or 8,760 hours per year,

the 180 million duty engine would show the lowest annual cost. It would also show the lowest annual cost at 6,000 hours a year if the coal cost $6 per ton. With very cheap coal, on the other hand, the low duty engines would make a much better showing.

The above will serve to illustrate the method by which a computation to determine the most economical engine for a given place may be made, and by substituting actual figures for those assumed in the table a correct idea as to the engine of greatest economy can be gained with very little labor.

Tabular Statement of Total Annual Cost of Pumping with 800-HP. Engine, as Influenced by Varying Duty of Engine, Varying Price of Fuel, and Varying Time of Operation.

	Duty per million B. T. U.				
First cost:	50.	100.	120.	150.	180.
Engine	$24,000	$48,000	$68,000	$118,000	$148,000
Engine, per HP..	30.00	60.00	85.00	147.50	185.00
Boilrs, econmars	27,000	13,500	11,250	9,000	7,500
Engine & boilers	51,000	61,500	79,250	127,000	155.500
Int. and depreciation:					
On engine, at 6%	1,440	2,880	4,080	7,080	8,880
Boilers, 8% ...	2,160	1,080	900	720	600
Total	3,600	3,960	4,980	7,800	9,480
Labor per annum.	6,022	6,022	7,655	9,307	10,220
Fuel cost:					
4,000 hrs. per yr.:					
$3.00 per ton..	17,280	8,640	7,200	5,760	4,800
4.00 " " ..	23,040	11,520	9,600	7,680	6,400
5.00 " " ..	28,800	14,400	12,400	9,600	8,000
6,000 hrs. per yr.:					
$3.00 per ton..	25,920	12,960	10,800	8,640	7,200
4 00 " " ..	34,560	17,280	14,400	11,520	9,600
5.00 " " ..	43,200	21,600	18,600	14,400	12,000
Total average cost:					
4,000 hrs. per yr.:					
Coal, $3 per ton ..	26,902	18,622	19,835	22,867	24,500
$4 " " ..	32,682	21,502	22,235	24,787	25,100
$5 " " ..	38,422	24,382	25,035	26,707	27,700
6,000 hrs. per yr.:					
Coal, $3 per ton ..	38,522	22,942	23,435	25,747	26,900
$4 " " ..	44,182	27,262	27,035	28,627	29,300
$5 " " ..	52,822	31,582	31,235	31,507	31,700

Proofs of the above article were submitted to the builders of the two engines, with an invitation to submit comments, and we present their replies as follows:

Sir: We are in receipt of your favor of Aug. 29, enclosing proofs of proposed paper on "The Conditions of Maximum Pumping Engine Economy." We notice the statement is made that the Chestnut Hill engine had no feed water heater. This is an error (since corrected—Ed. Eng. News) into which you were possibly led by our letter to you of Aug. 21. The Boston engine has one feed water heater located in the exhaust pipe, immediately over the surface condenser, but it was not used during the official test, because the feed water during the test was the actually condensed steam received from the engine, which under ordinary conditions is thrown away on account of the cylinder oil, the feed water being taken from the outboard circulating pipe and passed through the heater. It being inconvenient to alter the regular feed pipe arrangement, it was decided not to use the exhaust and heater on the official test. Please note that the temperature of exhaust in the condenser was about 90° Fahr., and that under normal conditions the temperature of feed water entering the heater would be about 79°. Under these circumstances only a very small net total gain could be expected, particularly when, as in this case, an economizer was used.

Aside from the above correction we have no comment to offer on your article, which seems to us a very fair and impartial statement of the case. Yours truly,

The Edward P. Allis Co.

Milwaukee, Wis., Sept. 4, 1900.

We have also been favored by The E. P. Allis Co. with a table, which we print herewith, showing the principal data of tests of twelve large pumping engines which have shown high-duty records:

Sir: You ask me to make some comments upon your article entitled "The Condition of Maximum Pumping Engine Economy," and as such it would appear to me that it is extremely unfair to credit an engine with the gain in economy resulting from the use of an economizer. To show the unfairness of this, let us assume that the heating surface of the boilers used with the Chestnut Hill pumping engine had been very much smaller than it actually was, and that the surface of the economizer was increased proportionally. The result would have been that water would have entered the actual boiler with a higher feed water temperature than was found on the test. The duty would, in this case, of course, have been much higher than the figure you name, while the coal consumption would not have been reduced.

In all comparisons of this kind the economizer ought to be regarded as part of the boiler. The question whether the high economy of my engine was the result of quadruple expansion, or was due to the heating system, I believe is fully answered by Professor Thurston in his paper read before the American Society of Mechanical Engineers last December. After the duty test of this engine was completed, Professor Carpenter insisted upon making a test without the heater in operation; that is, working the engine as a quadruple expansion engine, returning to the boilers only the heat from the steam jackets. The result of this test is given in Professor Thurston's paper, the comparative figures being as follows:

	With heater.	Without heater.
Duty per million B. T. U.....	162,948,824	147,525,000
Per 1,000 lbs. of steam.....	150,254,138	139,824,700

The cylinder proportion in this engine was selected with reference to this heating system. If it had been the intention to produce a low steam consumption, a different proportion would have been adopted. The fourth stage was adopted only to get one more step in the regenerator.

There is no doubt that had we used an economizer with the Wildwood pumping engine a material increase of duty would have been the result. In fact, the conditions at Wildwood were extremely favorable for doing this.

In all articles and discussions regarding our pumping engine at Wildwood the fact seems to have been lost sight of entirely that my system of heating feed water enables the use of any steam pressure that practically can be carried on boilers, and I believe that with this heating system a new field for attaining higher economies is opened. It is, of course, plain that the higher the boiler pressure the greater will be the proportion of heat which has to be supplied to the feed water, and the smaller the proportion of the heat which can be transformed into work. With my system of heaters we draw upon both the sensible and latent heat in the steam for work.

The table which you have prepared showing the relative cost of the operation of engines designed for high and low duty I think is not correct. In the first place, there is no reason why a higher priced man should be employed on an engine developing 180,000,000 duty than on one developing 100,000,000 duty. Then, again, the comparative first cost of different grades of engines is too high in case of the high duty engines. The comparative cost of a pumping engine depends largely upon the head pumped against, and it will be found that pumping engines pumping against a high water pressure will show a greater difference of cost, due to difference in economy, than engines pumping against lower pressures.

I have serious doubt about the St. Louis engine running with a friction of 3%. As I understand it, this engine is fitted with single-acting plungers, by which arrangement considerable friction in transmission of work between crank shaft and engine is produced. With such arrangement, I do not think a friction of much less than 9% be obtained. Yours respectfully,

Bruno Nordberg.

Milwaukee, Wis., Aug. 31, 1900.

Mr. Nordberg makes a good point against crediting an engine with the gain in economy resulting from the use of an economizer, by showing how the apparent duty of an engine might be increased without diminishing the fuel consumption, by merely using less heating surface in the boiler and more in the economizer.

Nevertheless it seems to us fair to consider the economizer as much of an appurtenance of the engine as the feed water heater is, provided that as in the case of the Allis engine, the economizer does not use heat which would ordinarily be used by the boiler, but uses only heat which the boiler necessarily has to throw away. In the test of the Allis engine the flue gases discharged from the boiler had a temperature of only 485°, which is about as low as it is possible to obtain when the temperature of the steam in the boiler is 382°. The economizer reduced them to 222°, and raised the temperature of the feed water from 80° to 155°.

This increase of temperature was obtained by utilizing heat which would otherwise have been thrown away in the chimney gases.

In the Nordberg test the feed water temperature was successively 193°, 260° and 311°, after it had passed through the heaters supplied with steam from the three receivers, which steam was still capable of doing work in one or more cylinders.

Both devices, the Nordberg system and the economizer system, are devices for saving fuel, and not merely for obtaining a high duty record, and it seems quite proper to compare one with the other, and, under the given conditions, to consider each, for the purpose of comparison, as part of the engine. It is evident enough from the above discussion that each of these devices is effective, and probably a combination of both would give a higher economy than either one alone.

We do not claim even approximate accuracy for the figures in the table of annual costs; they are only given to illustrate the method of computation and to show the influence of different factors upon the final result.

LETTERS TO THE EDITOR.

Notes Awheel in the Adirondacks and Northern Vermont.

Sir: During the past four or five years I have ridden (and pushed) my wheel many hundred miles in the Adirondacks and in the northwestern portion of Vermont. My trips in the mountains have been less tedious than one unfamiliar with the roads there would suppose. Many of the main roads have comparatively easy grades; the old post road, for instance, from Plattsburg to Albany, has few bad hills, except over the mountains from the Schroon River to Lake George. The worst two features of these mountain roads, aside from grades, are sand and mud. The latter is encountered for brief periods only, right after rains, except along some of the heavily wooded roads. Often this mud might be prevented at very slight expense, if only some simple drainage work were done. Thus, in the beautiful Keene Valley, a few miles north of Mt. Marcy, I encountered a veritable quagmire close by

RECENT AMERICAN PUMPING ENGINES WITH HIGH-DUTY RECORDS.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Builder or designer	E. P. Allis Co.	E. D. Leavitt, Jr.	Lake Erie Eng. Wks.	SnowSteam Pump Co.	E. P. Allis Co.	Nordberg Mfg. Co.	E. P. Allis Co.	E. P. Allis Co.	E. P. Allis Co.	E. P. Allis Co.	E. P. Allis Co.	E. P. Allis Co.
Locality	Milwaukee.	Boston.	Buffalo.	Indianapolis.	Cleveland.	Pittsburg.	St. Louis.	St. Louis.	Hackensa'k	St. Louis 9.	St. Louis 10	Boston.
Triple or quadruple expansion	Triple.	Triple.	Triple.	Triple.	Triple.	Quadruple.	Triple.	Triple.	Triple.	Triple.	Triple.	Triple.
Extent of jacketing	Barrels and receivers.	Bbls.,heads & recvrs.	Bbls. and receivers.	Bbls.,heads & recvrs.	Barrels and receivers.	Barrels and receivers.	Barrels and receivers.	Barrels and receivers.	Barrels and receivers.	Barrels and receivers.	Barrels and receivers.	Bbls. and receivers.
Name of experts conducting test	Prof. R. C. Carpenter & J. H. Lewis.	Prof. E. F. Miller.	G. H. Barrus, and N. Carlton.	Prof. W. F. M. Goss.	Engr. of W. Dept. & J. H. Lewis.	Dept. Expr. Eng., Sibley College.	Messrs. Holman, Laird and West.	Messrs Holman, Laird and West.	Prof. J. E. Denton and A. J. West.	Eng'r Water Johnson and West.	Dept., Nils A. J.	D. Brackett, W. J. Sando and A. J. West
Capacity, galls. in 24 hours	18,000,000	20,000,000	30,000,000	20,000,000	20,000,000	6,000,000	10,000,000	10,000,000	12,000,000	15,000,000	15,000,000	30,000,000
Size of steam cylinders	28, 48, 74 x 60 ins.	13.7, 24.37, 39x72 ins.	37, 63, 94 x 60 ins.	29, 52, 80 x 60 ins.	34, 62, 92 x 64 ins.	19.5,29,49.5 57.5x42 ins.	30, 54, 80 x 64 ins.	30, 54, 80 x 64 ins.	25½, 47, 73 x 42 ins.	34, 62, 92 x 72 ins.	34, 62, 92 x 72 ins.	30, 56, 87 x 66 ins.
No. and size of water plungers	(3) 32 x 60	(3) 12.5x48	(3) 48x60	(3) 33x60	(3) 34x64	(2) 14⅝x42	(3) 25½x64	(3) 25½x64	(3) 25½x42	(3) 29½x72	(3) 29½x72	(3) 42x66
Plungers: Single or double acting.	Single.	Double.	Single.	Single.	Single	Double.	Single.	Single.	Single.	Single.	Single.	Single.
Piston speed, per minute	203.1 ft.	607.0 ft.	207.7 ft.	211.8 ft.	199.78 ft.	255.6 ft.	175.36 ft.	175.25 ft.	210.63 ft.	197.64 ft.	197.16 ft.	195.089 ft.
Date of contest	1893.	1895.	1897.	Dec. 3, '98.	March, '99.	March, '99.	June, '99.	June, '99.	Jan., 1900.	Feb., 1900.	Feb., 1900.	May, 1900.
Total head in lbs.	70.40	59.4	86.1	89.2	87.57	261.5	127.25	127.25	115.47	126.94	126.48	60.77
Total head in ft.	162.6	137.21	199.0	206.05	202.25	504.06	293.89	293.9	266.6	293.18	292.11	140.35
Steam pressure (near throttle)	121.4	175.7	167.1	154.6	149.4	200.0	136.0	137 0	173.0	126.90	126.2	185.47
Ratio of expansion	20.4	21.0	19.6	22.4	....	....	....	....	....	....	....	....
Indicated horse-power	573.9	575.7	1185.5	782.9	770.44	712.2	548.71	544.93	602.8	812.7	801.6	801.57
Friction, %	9.2	10.5	5.1	6.2	6.28	6.95	5.74	5.13	5.94	4.03	3.16	6.71
Mechanical efficiency	90.8	89.5	94.9	93.8	93.72	93.05	94.26	94.87	94.06	95.97	96.84	93.29
Dry steam per I. HP. per hour	11.68	11.22	12.39	11.38	11.45	12.26‡, 11.4‡	11.627	11.63	11.05	10.776	10.676	10.335
B.T.U. per I. HP. per minute	217.6	204.3	231.2	209.9	213.18	185.96	216.84	216.51	211.9	204.37	201.96	196.08
Duty*, expressed in million ft.-lbs.	137.7	144.5	135.4	147.5	145.22	162.9†,147.5‡	143.4	144.4	....	155.24	158.07	†163.9, 156.8
Duty, per 1,000 lbs. dry steam	154.0	158.0	152.0	163.2	161.99	150.2	160.45	161.53	168.53	176.48	179.45	178.49

*Based on million B.T.U. †B.T.U. duty on water entering boiler. ‡With reheaters. ‡Without reheaters.

the East Branch of the Ausable River. There was scarcely room or need for a ditch between the road and the river, but the bed of the road was 18 to 24 ins. below its sides, so that water could drain off only by slow percolation. What this has been effected the road in question is said to be fine. A few miles to the south the Adirondack Road Association has built a gravel road from St. Hubert's Inn to the Lower Ausable Lake, which is all any one could ask in the way of roadbed. The grade is rather steep, of necessity. The road is in a heavy green-wood, winding along much of the way by a merry stream, and is a delight, indeed.

The road west from Schroon River post office to Long Lake, some 45 miles, is hilly and bad, and the road from Elizabethtown to Lake Placid, 30 miles, is also very hilly, though less bad otherwise, but the mountain and lake scenery along either route repays one for the exertion.

It is harder to suggest a remedy for the weary sand stretches, quite frequently met in the Adirondacks, than for the mud; that is, a remedy warranted by the light traffic of the section. Shavings and boughs are used on the hills and materially lessen the demands on horses. There is a particularly dreary stretch of sand just north of Keeseville, not far from Ausable Chasm. Grass can scarcely keep a root hold there, and in one instance I saw stones used to hold down a door yard.

Near Lake Champlain a stiff, heavy clay soil is encountered, and the roads are badly rutted. Except for side ditches little seems to be done to make these roads tolerable, but I have shunned them whenever possible and so may have missed some improved sections.

In northwestern Vermont I have generally found the roads much better than in the Adirondacks, although decidedly hilly. The soil is often clayey, where I have ridden, but the clay is not so heavy north and east of Burlington as on the other side of the lake and more gravel is used in repairing the roads. In or near Fairfax I found men improving a stretch of bad clay road by excavating a flat V-shaped trench with a road machine, filling it with large stone, as big as one's head, and then covering the stone with gravel. I suggested that smaller stone might be better, but the men on the job said a similar stretch of work had been down six or seven years with good results.

Between the trolley tracks near Fort Ethan Allen (northeast of Burlington) I found an excellent cycle path. The tracks are at one side of the highway and no ordinary traffic passes over the space between them. Why not have more such cycle paths between street railway tracks in rural and perhaps in suburban districts, where the cars do not run frequently?

Wheelman.

Elizabethtown, N. Y., Sept. 7, 1900.

Notes and Queries.

In reply to "W. S.," who inquired the meaning of the term "watch tackle," Mr. R. F. Bennett, New Haven, Conn., sends us the following:

"Watch tackle" in pile-driving means a small hand tackle, say one composed of 5 or 6-in. blocks with a rope ¾-in. in diameter. The number of sheaves in an ordinary wooden block of this size and kind should not be greater than two unless they are supplied with roller bushings, in which case three sheaves is probably the limit. It has been determined by experiment that, with a given load, the pull necessary to exert on the fall of a tackle of that size and kind is increased rather than diminished by employing a three-sheave block rather than a two-sheave, when the bushing is any other than roller. This is due to the tipping of the blocks, and the consequent rubbing of the sheaves against the sides of the mortises. The above definition of "watch tackle," with little doubt, applies in "bridge erection" as well as in pile-driving.

The standards of track construction on American railways, which were tabulated in our issue of August 30, contains a few inaccuracies in the description of the Pennsylvania R. R. standards, owing to errors in the information from which the tables were compiled. The corrections are as follows:

Table No. 1.—The bolts for 70 and 85-lb. rails are 13-16 × 4½ ins. under the head; those for 100-lb. rails are 1 × 5 ins.

Table No. 2.—The ties are of white oak, at least 7 ins. wide on the face, and cost 57 to 70 cts. each. There are 14 and 16 ties to a 30-ft. rail length, and some experimental treated ties are in use. The tie-plates are of the Pennsylvania R. R. pattern, and are used on soft wood ties. The depth of ballast is 8 to 12 ins.

Table No. 3.—There is no standard for curve guard rails.

Prof. H. S. Jacoby, Cornell University, calls our attention to the fact that, in the table showing the main dimensions of the notable long span steel arch bridges in the world, published in Engineering News of Sept. 6, 1900, Richmond, Md., should read Richmond, Ind. He also states that two other arches should be added to the list as having spans of more than 100 m. (328 ft.), viz.: Lake St. Bridge, Minneapolis, Minn., road; wrought iron; span 139 m.; rise, 27.4 m.; ratio, 5.1; and the Panther Hollow Bridge, Schenley Park, Pittsburg, Pa., road; steel; span, 109.7 m.; rise, 13.7 m.; ratio, 8. Mr. Charles F. Loweth, M. Am. Soc. C. E., also calls attention to the Marshall Ave. Bridge crossing the Mississippi River between St. Paul and Minneapolis, Minn., regarding which he says:

This bridge comprises two arch spans, each 456 ft. c. to c. of end pins, divided into 24 panels of 19 ft. The arches have three hinges, with a rise of 90 ft., and are 6 ft. deep at the crown. The distance between end pins over the center pin is 19 ft. The ribs are vertical and 29 ft. apart c. to c. The structure carries an 18-ft. 6-in. roadway and two 5-ft. 10-in. sidewalks, and is of wrought iron. It was built by the Wrought-Iron Bridge Co., of Canton, O., for the counties of Ramsey and Hennepin jointly, and was completed in 1889 or 1890. Mr. Joseph S. Sewall, C. E., of this city, was the designer, and supervised its construction.

It may also be noted here, in addition to the bridges noted above, that a 355-ft. steel arch road bridge has recently been completed at Waterport, N. Y.

THE USE OF ALUMINUM WIRE FOR ELECTRIC TRANSMISSION LINES.*

F. A. C. Perrine† and F. G. Baum.

Up to the present time, discussions of the use of aluminum wire in line construction have considered only the relative prices of copper and aluminum wires, the conductivity, tensile strength and other properties of the aluminum wire being considered merely as determining its relative price. During the past year the manufacturers of aluminum have demonstrated their ability to sell this wire at a price well below twice the price of copper per pound, and in consequence the new material has forced itself upon our notice and has demanded that we consider carefully all of its properties. Having recently been led to purchase a considerable amount of this wire by reason of the high price of copper and the low price of aluminum, the writers have made a careful study of the wire supplied, and now present the results obtained in hope that they may be of service to other engineers.

The line for which this wire was purchased is about 43 miles in length, and the country through which it runs varies in elevation from about 100 ft. above the sea level to at least 2,000 ft.; one-half lying in almost a straight line through a country nearly level, while the remainder is over the mountains, through which the line runs almost straight, surmounting high hills and descending into deep gulches. In some cases the lengths of the poles were proportioned to decrease the vertical line deflection, but as an accurate preliminary survey was not available, much less grading of poles was possible than would have been desirable. This defect in pole setting was largely remedied in the wire stringing by drawing a number of spans at one time, so that at depressions and elevations there was very little up or down strain put on the wire when it was tied to the insulators. The standard pole used was of redwood, 30 ft. in length, 7 ins. square at the top, and tapering to 12 ins. square at the butt, or about 11 ins. at the ground line 5 ft. above the butt. Each pole was gained for three cross-arms 20½ ins. between centers, the gains being cut ¾-in. deep, into which the cross-arms were bolted by single ¾-in. through bolts. The arms themselves were 4 × 4-in. Oregon pine bored for two pins each, the top and bottom arms being 3 ft. in length and the center arm 4 ft. The wires were arranged in a hexagon, 24 ins. on a side.

This system of construction presents some advantages for three-phase working at high voltages for long lines, especially where the two sets of circuit are to be operated from the same bus bars. If both wires on each arm are at the same potential, the arrangement of each circuit is that of an equilateral triangle, each side being 41 ins., while the minimum distance for leakage between any two wires of different phases is 36 ins. of cross-arm and 20 ins. of pole. The length of the longest arm necessary is much less than that in any other system of construction; the pole head is symmetrically loaded, and for these reasons the pole construction is exceptionally stable under all stresses.

The insulators used were of the flat topped, glass, triple petticoat type, about 5 ins. in height and 7 ins. in diameter, with a wire groove of about .35 ins. radius. The insulators are supported by eucalyptus pins of a length to give a distance of 4 ins. between the bottom of the insulator petticoat and the cross-arm; eucalyptus wood having been used on account both of its availability in California and its great strength, which latter is of extreme importance in the construction of pins of such lengths.** For further insulation and preservation, the cross-arms were creosoted by a treatment in which the timber was first carefully dried and then injected with 10 lbs. of dead oil of coal-tar to the cubic foot, an operation requiring approximately 13 hrs. for its completion. The pins were boiled at a temperature of about 225° F. for about 8 hrs. in a compound of coal tar and asphaltum, which gave a better external surface than the creosote. This latter coating did not penetrate the wood materially, but after experimenting extensively with this wood at temperatures up to 225° F. and pressures up to 160 lbs. per sq. in. without effecting any appreciable penetration of this wood, either with creosote or other extremely fluid materials, all idea of the use of a penetrating compound was abandoned, and an endeavor made only to obtain a coating which would provide the most complete external protection.

On this line as erected, the arms were braced by a bent angle-iron brace, but this precaution seems now to be entirely unnecessary, and a subsequent line belonging to the Yuba Power Co., erected on much the same plan, is not braced at all. For arms of over 5 ft. in length a brace is certainly advantageous, though for high potential service the braces should be of wood mortised into the cross-arms and nailed to the pole face.

The above complete physical details of the construction are unnecessary for the discussion of aluminum line wire, though it is believed that its stability when erected depends upon a careful study of all such conditions.

The line as erected carried only four wires arranged on the top and bottom cross-arms at the corners of a rectangle 24 ins. on the short side and 41 ins. on the long side. This arrangement was adopted for the purpose of making temporary use of some two-phase machinery which was in place and underloaded, allowing certain new customers to be taken on quite a year in advance of the contemplated completion of a three-phase plant for which the pole line was really designed. It was at first feared that this arrangement of the wires would result in inductive disturbances between the phases, as the wires were at the diagonally opposite corners of a rectangle, instead of the corners of a square, as is necessary for complete absence of mutual induction, but the anticipated trouble was not found. Careful measurements were made with one phase short-circuited and the other carrying about 20 amperes with a periodicity of 60 cycles per second, both with a Weston 75-volt voltmeter and a Rowland electro-dynamometer, with the result that no deflection was observable on the voltmeter, while the current read on the electro-dynamometer amounted to only about .001 ampere, the resistance of the dynamometer being 25 ohms and of the line 90 ohms. Only one further matter of installation needs attention, which is the presence on the tops of the poles of a barbed wire stapled to the wood of the pole and grounded at every fourth pole by a galvanized iron wire leading down along the pole and soldered to an iron plate 18 ins. square and ¼-in. thick, set in the pole hole immediately under the foot of the pole itself. This wire was intended as a lightning guard, and it has apparently done very effective service in discharging the line in all weather.

The wire used was intended to be equal to No. 3 B. & S. gage copper wire in its electrical resistance, and the manufacturers were required to furnish this conductivity in a wire not weighing more than 420 lbs. per mile. All the wire supplied was carefully inspected by Dr. A. E. Kennelly, and his reports give the following averages for the total quantity:

Diameter	293.9 mils.
Wt. per mile	419.4 lbs.
Resistance per mil ft.	17.6 ohms at 25° C.
Resistance per mile at 25° C.	1.00773 ohms.
Conductivity compared with copper.	59.9% by dimension.
Tensile strength of wire	1,549 lbs.
No. of twists in 6 ins. for fracture.	17.9
Tensile strength per sq. in.	32,898

Comparing this with copper it is seen that this wire is approximately the same as copper in the following sizes:

Size of aluminum wire	= No. 1 B & S copper
Resistance of " "	= No. 3 " "
Tensile str'gth " "	= No. 5 " "
Weight of " "	= No. 6 " "

Therefore, on the basis of the same conductivity the aluminum compares with copper as follows:

Diameter for the same conductivity	1.27 times copper
Area " " "	1.64 " "
Tensile strength " "	.629 " "
Weight " "	.501 " "

The mechanical properties of this wire present some well marked characteristics. In the first place, the number of twists necessary for fracture varies considerably, although the ductility test of wrapping six times around its own diameter, unwrapping and wrapping again is well sustained. This irregularity in the twisting test is generally a mark of impurity in wire, but we know so little as yet of the exact characteristics of aluminum, and the twisting test is in general so unreliable that it is unsafe to base any exact statement on this one test, particularly as the wire after erection proved reliable. In carefully performing the test for tensile strength no exact point could be assigned for the elastic limit, as the metal seemed to take a permanent set almost from the first, but at a stress of from 14,500 lbs. to 17,000 lbs. per sq. in., there is a marked increase in the permanent set, which indicates that the safe working load lies somewhere in this region. In this the characteristics of the aluminum do not differ materially from those of copper or other similar metals, and while this is a disadvantage it is not a singularity. The fact that the wire will permanently elongate if seriously strained, makes it necessary to use the utmost care in the erection of lines, and, also, the known high coefficient of expansion with temperature changes, taken in conjunction with this property, renders care in line stringing especially important.

For the purpose of ascertaining exactly what were the changes with temperature that might be anticipated, the Pittsburg Reduction Co. undertook a series of experiments with 200-ft. spans of wire at temperatures varying between 6° F. and 55° F., and at the same time the authors carried on a similar series of experiments on a 150-ft. span at the Leland Stanford, Jr., University in which the temperatures varied between 20° F. and 80° F. From the results of these experiments a coefficient of expansion with temperature was obtained, which was used in calculating sets of tables for the instruction of the line foreman, which gave the tensions and deflections at the different temperatures encountered. These tables were cal-

*Abstracted from a paper read before the American Institute of Electrical Engineers.

†President Stanley Electric Mfg. Co., Pittsfield, Mass.

**Tests of a large number of pins made of eucalyptus, oak and locust show that the eucalyptus has about 20% more strength than locust and 30% more than oak.

culated by use of the ordinary approximate formula for the tensions and deflections of a suspended wire, and the method used for obtaining the coefficient of temperature expansion removes the usual objection to the formulæ that they do not take into account the elasticity of the wire itself, which produces serious errors if an attempt be made to use the true coefficient of linear expansion with changes of temperature. In fact, the coefficient of linear expansion obtained from these experiments is less than one-half the value of the true coefficient of linear temperature expansion, but its use is justified by the fact that the tables as calculated have been frequently verified experimentally, both at the testing stations and in the field while the line was being strung. As a result of these tests the Pittsburg Reduction Co. has issued a table of deflection tensions and temperatures.*

A copy of the table of deflections was issued to the line foreman, together with the following instructions. He was also provided with a thermometer, a dynamometer and a pair of targets for measuring the deflections:

1. All spans are to be strung with deflections and tensions as specified in table.

2. Up and down hill spans to be sprung to correspond with level spans. In case level spans cannot be used, then employ dynamometer, and ease all wires over cross-arms.

3. All ties are to be made at one time by signal.

4. All ties are to be made by crossing wires around insulator serving three times around wire, and twisting behing insulators; the ends of the tie-wires are not to be cut, but bent back toward insulators.

5. Tie all wires on the outside of the insulators, except at corners where all are to be tied so that the strain is against the insulator.

6. Joints are to be made by means of sleeves twisted two and a half times, the ends of the wires being given one turn by hand around the wire. No tools are to be used, except in twisting the sleeves and cutting off the ends of the wires. Before inserting the wire in the sleeve, the ends of the wire must be roughened by draw filing.

7. Barbed wire is to be laid along the roofs of the poles and held by three staples driven in tight, but without kinking the wire. Ground wires are to be soldered to the barbed wire and at the bottom of the pole to the wire leading from the ground plate. All soldering acids must be carefully washed away after the soldering is done.

8. Beginning between poles one and two, all wires are to be barreled by shifting one pin, and same to be repeated between poles 21 and 22 and 41 and 42, and so on. Barreling always in the same direction of twist every twenty poles. A record must be kept of the location of every wire and every pole.

General Caution.—The greatest care must at all times be taken against kinking or scarring the wire; wherever the wire is accidentally kinked or scarred it must be cut and spliced.

The targets mentioned above consisted of light sheet iron strips about 2 ft. long and 2 ins. wide, with an aluminum hoop bent into an eye at the top, by means of which they could be hung from the line wire. These targets were painted in three or four colors, with bands 1 in. wide. In use, the captain of the linemen would hang his target to the wire to which a man on the next pole had also hung a target; then, as the wire was being pulled into place, he would sight from a band on his target to the same band on the adjacent target, and when the wire came into line with these two bands the signal would be given for all the linemen to tie at once. As a result of this method of stringing, an exceedingly uniform line was obtained.

One of the most serious problems in connection with the use of aluminum is in the choice of a proper joint. This metal is so highly electro-positive that it is unsafe to expose it to the elements in contact with any other material, as electrolytic corrosion is almost sure to follow such construction. Many of the failures which have been reported of this metal have been due to a neglect of this fact; as notably in the case of the plates on the yacht "Defender," where the plates have been corroded at the contact with the bronze rivets used in fastening them to the frame. Whenever this metal is soldered or used in contact with any other metal, the joint should be thoroughly waterproofed to prevent such action. After discussing many joints, it was finally determined to abandon any attempt to solder or clamp the wire in any manner, and the joints were made by slipping the ends of the wire into an oval aluminum tube about 9 ins. long, which was then twisted with a pair of clamps similar to those employed in twisting the McIntire connector. After twisting the tube, a turn was taken by hand of the loose ends and the wire cut off close. The joint produced proved practically equal to the original wire in both tensile strength and electrical conductivity.

This wire was erected during the winter of 1898-99, which was an unusually open winter over the whole State of California, allowing practically continuous construction work, though the temperature varied all the way from about 30° F. to 80° F. at times when the wire was being strung. After it was finally erected it remained about three months on the poles before the machinery was delivered and put in place. During the first month of that time three breaks occurred which were all apparently due to flaws in the material, but after these breaks were repaired the line wire gave absolutely no trouble whatever, although various accidents occurred to other parts of the construction. Many insulators were shot at and broken, bale wire and bale rope was thrown over the line, a twig short-circuited one phase and fell down burned, a large bird was killed by contact with the wires, and finally several porcelain insulators with porcelain pins were broken off and hung suspended by the wire. In January and February of the present year this whole line was taken down to give place to a much heavier one of the same material, an opportunity for such a total change having been found after the total destruction of the power-house by fire last November.

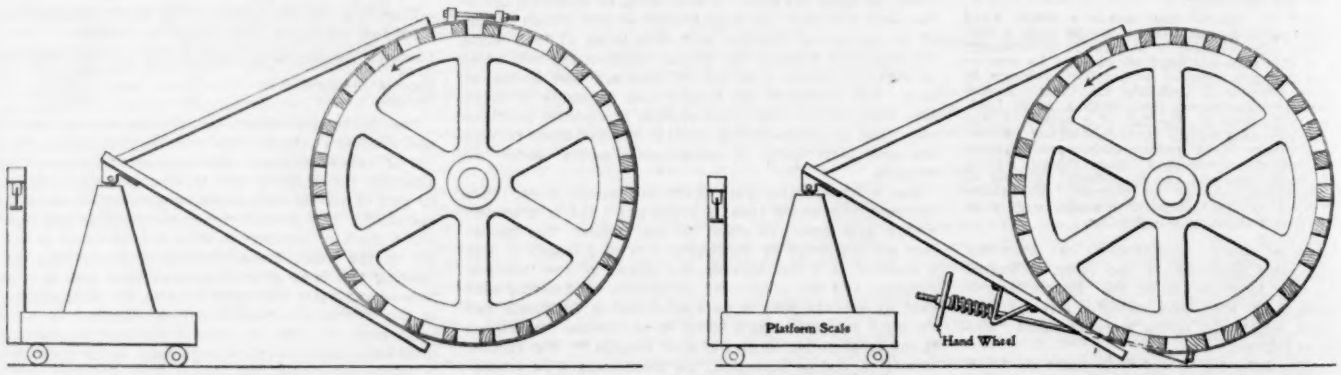
During the past two years other lines of aluminum wire have been erected on the Pacific Coast, all but one of which have given a considerable amount of trouble from causes that are not entirely apparent. One line in Nevada county, erected at about the same time as that we have been describing, and for which the wire was of practically the same lot, has given no trouble whatever. The power transmission lines of aluminum wire about Seattle have broken a few times, but have not given serious trouble. The breaks in this line, so far as the writers have been informed, seem to have been due to not allowing enough sag at the higher temperatures, and a consequent overstraining of the wire in cold weather. The most serious difficulties have been encountered by the telephone company in Washington and Oregon and by the Yuba Power Co. In all of these cases it seemed almost impossible to keep the wires on the poles in certain sections, and in these sections the lines have been finally taken down and replaced by other wire of either copper or aluminum. The writers have examined many breaks from these lines, and would judge, from the appearance of the fracture, that the causes, whatever they might have been, were similar. In these breaks there are many small flaws, but by far the greatest majority are clear, sharp fractures, with but a slight reduction of area, and that entirely on one side, a break very characteristic of improperly mixed and brittle alloys. Partially from the appearance of the fracture and partially from the facts that the breaks occur only in certain sections of the line, the writers are of the opinion that this trouble is due to the presence of impurities in the material. This view is strengthened by the fact that when measurements were made on the line of the Yuba Power Co., the resistance of the whole line was found to be 10% greater than it should have been if it were made of the quality of material described in the earlier part of this paper. Furthermore, in one-half of this line there were no breaks at all due to defects in the wire itself.

As a general conclusion, it is the opinion of the writers that aluminum can be safely used in place of copper where the proper precautions are taken in inspecting the wire before it is erected, and in erecting it with due consideration of its peculiar properties of low and indefinite elastic limit, high coefficient of temperature expansion and active electrolytic power. As indicating our faith in this opinion, it may be noted that for the new line soon to be erected an aluminum strand ¾-in. in diameter has been ordered. This strand will be spliced with aluminum sleeves, and in the whole construction about one million pounds of aluminum will be employed.

*Copies of this table may be obtained by addressing the Pittsburg Reduction Co., Pittsburg, Pa.

AN IMPROVED PRONY BRAKE.

The modification of the Prony brake shown in Fig. 2 is described by Mr. E. J. Armstrong in a recent number of the "American Machinist," from whose columns we reproduce the accompanying illustrations. The conventional form of the brake is shown in Fig. 1. The torque of the brake is regulated by adjusting the nut at A. Once adjusted, however, the torque is not apt to remain constant, especially at heavy loads, on account of changes in the condition of the surfaces of the brake and the wheel, and, hence, in the coefficient of friction. With the arrangement shown in Fig. 2, this adjustment may be made much more accurate and permanent. By introducing a spring under the hand-wheel the tension on the brake at this point becomes nearly constant, and, as this is the point of maximum tension, the torque is also constant. For wide ranges of load it is best to have several springs corresponding in stiffness to the different loads.



AN IMPROVEMENT TO THE PRONY BRAKE.

DIFFUSION OF LIGHT BY GLAZING and glass of different kinds is to be made the subject of careful tests by the Boston Manufacturers' Mutual Fire Insurance Co. The tests will be conducted by Mr. Charles L. Norton at the Massachusetts Institute of Technology. In the Walker Building of this institution there is a large room 60 ft. wide, lighted on each side, and of such height as closely to correspond to a room in a factory of that width. There are also basements in which tests of deflection as well as diffusion may be made in the most thorough manner. The representative of each type of prismatic, of rectilinear or curvilinear glass has been requested to contribute examples of glass and to give such supervision and attention to the matter as may assure each and all contributors of the absolutely impartial methods adopted for comparison. Several representatives of different types of glass have contributed the glass and have also contributed toward the expense of the undertaking. Others have declined, but examples of their glass have been secured, and if they do not choose to exercise any supervison in order to be assured of the impartiality of the test, the undertaking will go on without their co-operation. In the final report the names will be given of those who have contributed and of those who have declined to meet the test. This is the second series of tests of this kind, and copies of the report on the previous tests can be obtained by addressing the association at 31 Milk St., Boston, Mass.

SCIENTIFIC FORESTRY IN SWEDEN is a profitable venture, according to a recent consular report. There are now in Sweden 18,000,000 acres of public forest, of which 12,500,000 acres are under scientific management. The export of forest products in 1897 amounted to $97,662,700. There is in Sweden a central forestry bureau, a forestry corps for work in the field comprisng nine inspectors, 88 chiefs of range having equal rank with captains in the regular army, besides many foresters and watchmen. The state forests average 166,250 acres in each range. There are a college of forestry and six schools of forestry. For forestry management, administration and instruction the state annually expends, according to the report of 1898, $423,659. The income to the state from forestry the same year was $2,104,412, the forest at the same time growing more valuable every year.

THE NOBEL PRIZES FOR SCIENTIFIC DISCOVERIES are reported upon by the U. S. Legation to Sweden and Norway in a recent issue of "Consular Reports." The first award will take place on Dec. 10, 1901. The Nobel endowment is based on the will of Dr. Alfred Bernhard Nobel, Engineer, drawn up Nov. 27, 1895. The stipulations are as follows:

The remainder of the fortune which I shall leave shall be disposed of in the following manner: The capital, con-

verted into safe investments by the executors of my will, shall constitute a fund the interest of which shall be distributed annually as a reward to those who, in the course of the preceding year, shall have rendered the greatest services to humanity. The sum total shall be divided into five equal portions assigned as follows:

(1) To the person having made the most important discovery or invention in the department of physical science.

(2) To the person having made the most important discovery or having produced the greatest improvement in chemistry.

(3) To the author of the most important discovery in the department of physiology or of medicine.

(4) To the author having produced the most notable literary work in the sense of idealism.

(5) To the person having done the most, or the best, in the work of establishing the brotherhood of nations, for the suppression or the reduction of standing armies, as well as for the formation and the propagation of peace conferences.

The prizes will be awarded as follows: For physical science and chemistry, by the Swedish Academy of Sciences; for works in physiology or medicine, by the Carolin Institute of Stockholm; for literature, by the Academy of Stockholm; finally, for the work of peace, by a committee of five members, elected by the Norwegian Storthung. It is my expressed will that nationality shall not be considered, so that the prize may accrue to the most worthy, whether he be a Scandinavian or not.

LARGE TEN-WHEEL PASSENGER ENGINES have been put in service by the Highland Ry., Scotland, to haul the heavy express trains of the summer and autumn, when the tourist and shooting seasons bring such heavy traffic that two or three ordinary engines are required for each train, as the main line has numerous grades of 1.43%. The engines have outside cylinders, and the firebox is between the two rear axles, 8 ft. 3 ins. apart. The tenders are carried in pairs of swiveling trucks. The engines were built by Dubs & Co., of Glasgow, to the designs of Mr. Peter Drummond, the Locomotive Superintendent of the Highland Ry. The general dimensions are as follows:

Driving wheels	5 ft. 9	ins.
Truck wheels	3 " 3	"
Wheelbase, driving	14 " 3	"
" truck	6 " 6	"
" engine	26 " 4	"
" engine and tender	52 " 5½	"
Length over engine and tender	60 " 7	"
Weight on driving wheels	98,224	lbs.
" on truck	33,600	"
" of engine	131,824	"
" of tender	85,344	"
" of engine and tender	217,168	"
Cylinders	19½ × 26	ins.
Boiler, rail to center line	8 ft. 2	ins.
Boiler pressure	180	lbs.
Tubes, 248; diam., 2 ins.; length	15 ft. 9	ins.
Heating surface, tubes	1,916 sq. ft.	
" " firebox	148 " "	
" " total	2,064 " "	
Grate area	26½ " "	
Height, rail to top of smokestack	13 ft.	
Water in tender tank	4,020 U. S. galls.	
Coal in tender	5 tons	

BOOK REVIEWS.

ELECTRIC WIRING, FITTINGS, SWITCHES AND LAMPS.—A Practical Book for Electric Light Engineers, Wiring and Fitting Contractors, Consulting Engineers, Architects, Builders, Wiremen and Students. By W. Perren Maycock, M. I. E. E., Consulting Electrical Engineer. New York: Whittaker & Co. Cloth; 5×7 ins.; pp. 446; 360 illustrations. $1.75.

This book is devoted to electric light wiring and fittings and treats wholly of English practice. It gives the usual methods of laying out circuits and describes and illustrates the fittings employed. In an appendix are added the wiring rules, adopted by the British Institution of Electrical Engineers.

"RESTRAINT OF TRADE," Pros and Cons of Trusts in Facts and Principles. A handbook for the man who wants to think clear and vote right, by Wm. Hudson Harper. Address "Restraint of Trade," 750 Marquette Building, Chicago: Paper, 12mo; pp. 368. 50 cts.

This book is a collection of quotations from a large number of writers and public men on the topic contained in its title. The extracts are well chosen and with an evident purpose to set forth the truth from a non-partisan standpoint. The information given in the book makes it useful as a work of reference, and the price at which it is sold is very small compared with the value of its contents.

ALLIS TRIPLE-EXPANSION PUMPING ENGINE, CHESTNUT HILL STATION, BOSTON WATER-WORKS.

(With full-page plate.)

In our issue of Aug. 23 last we published an account of a recent test made on a large pumping engine installed at the Chestnut Hill Station of the Boston Water-Works. We illustrate this engine on our inset sheet this week, and in our editorial pages we have discussed some features of the design of this engine and the duty obtained by it in comparison with other recent notable high-duty pumping engines.

It will be seen by the end view on the inset sheet that the engine is a very compact machine, and is so designed that its valve chambers constitute its support. Each pump plunger is placed directly under one of the steam cylinders and rigidly connected to the piston above it. The engine is designed to run at about 17½ revolutions per minute, giving a piston speed of only 192.5 ft. per minute. Its capacity at that speed is 30,000,000 gallons in 24 hours. Corliss valves are used on the h. p. cylinder and as inlet valves on the l. p. cylinder, but poppet valves govern the exhaust from the l. p. cylinder and both admission and release from the l. p. cylinder. All the valves are driven from a lay shaft, which is driven by connecting rods from the main shaft. An automatic fly-ball governor controls the cut-off in the h. p. cylinder, and this cut-off and that in the next cylinder are also adjustable by hand. The engine is equipped with steam jackets and intermediate reheaters, and has boiler-feed pump, air pump and air compressor for charging the pump air chambers connected directly to it.

A more detailed description of the machine was given in connection with the account of its test in our issue of Aug. 23, p. 125, and reference may be made to it for further information.

THE FRICTION OF BRAKE SHOES UNDER VARIOUS CONDITIONS OF PRESSURE, SPEED AND TEMPERATURE.*

By R. A. Smart, Jun. M. Am. Soc. M. E.†

The Brake Shoe as a Factor in the Operation of Trains.—The brake shoe is really an integral part of the air-brake system, and without an efficient brake shoe, the air brake cannot render its best service. By an efficient brake shoe is meant one having a comparatively high and uniform coefficient of friction and a reasonably long life. It is not only desirable that the coefficient of friction be high, but that it be fairly constant throughout the length of a stop. A shoe having a relatively low mean coefficient may be better than one having a higher mean coefficient, but whose friction increases greatly just before the stop, thus having a tendency to skid the wheels.

Need of Uniformity in Brake Shoes.—Brake shoes should give comparatively uniform performance. Assuming that all of the air brakes on a train of 50 cars gave a uniform performance, it would be highly undesirable to have the last 25 cars equipped with brake shoes having a high coefficient of friction, and the first 25 cars equipped with brake shoes having a low coefficient of friction. This would be almost equivalent to having the same train equipped with the same brake shoes, but with the leverage on the rear half of the train proportioned for considerably higher braking pressures, which would manifestly be undesirable. Hence, it may be said that it is necessary that there be uniformity in the frictional qualities of brake shoes, within certain limits. Unfortunately, this fact has not always received the attention which it merits.

Work of the M. C. B. Association in Connection with Brake Shoes.—To the Master Car Builders' Association is due, in a large measure, the credit for the advance which has been made in the manufacture and use of brake shoes, and for much of our present knowledge on the subject. It early recognized the importance of uniformity of action and through the standing committee on laboratory tests of brake shoes, of which Mr. S. P. Bush is chairman, has obtained the greater part of the information on brake shoes now at hand. In 1893, the association, through its committee, designed and built a machine known as the Master Car Builders' brake-shoe testing machine, the purpose of which was to determine, under conditions as nearly like those of service as possible, the coefficient of friction of different brake shoes under different working conditions.

The Plain Cast-Iron Shoe as a Standard of Reference in Testing.—In the later tests of the M. C. B. committee, and in subsequent tests made upon the M. C. B. testing machine, the performance of the different makes of shoes under test was compared with that of a plain soft cast-iron shoe, for three reasons: (1) the latter gives a relatively high coefficient of friction; (2) such shoes can be more readily duplicated than other kinds which might be chosen as standard, and (3) the results from such shoes are quite uniform. This shoe was designated by the committee as the "A" shoe, and was softer than the cast-iron shoes usually found in service. In the later commercial tests of brake shoes upon the M. C. B. machine, the results from two shoes have been taken as standards of reference. The first is the soft cast-iron shoe mentioned above, and the second is the one called by the committee the "B" shoe, and is of hard cast-iron. It is about the degree of hardness of the plain cast-iron shoe used in actual service.

The Desirability of Standard Specifications for Brake Shoes.—This process, while serving its purpose fairly well in the past, is open to many objections from the standpoints of the user, of the manufacturer, and of the tester of brake shoes. Recognizing this fact, the Master Car Builders' Association, at its 1900 convention, instructed the committee on tests of brake shoes to prepare specifications for brake shoes which should give the limiting conditions of the coefficient of friction under which brake shoes would be accepted. This is a timely act on the part of the association, and will do much to simplify the problems connected with the manufacture, purchase and testing of shoes.

The Variable Elements in Testing Brake Shoes.—In the commercial testing of any brake shoe on the M. C. B. testing machine, the usual variables are two in number: (1) the normal pressure between the shoe and the wheel, and (2) the peripheral speed of the wheel at the time the brake shoe is applied. The average coefficient of friction between the shoe and the wheel throughout the length of the stop varies for any given shoe with changes in these two factors. It is customary in ordinary cases to make tests at pressures ranging from about 2,800 lbs. to about 10,700 lbs., and at speeds ranging from 30 to 65 miles per hour, these limiting conditions embracing the usual conditions of operation on the road. The value 2,800 lbs. is taken to represent 70% of one-eighth of the light weight of a 60,000-lb. car, and 10,700 lbs. is taken to represent 90% of the weight on one wheel of a heavy passenger car.

There are three other variables which enter into ordinary tests of brake shoes: (1) the character of the wheel upon which the shoe is tested; (2) the temperature of the rubbing surfaces; and (3) the physical condition—that is (the comparative roughness or smoothness)—of the rubbing surfaces. The second and third are not under the control of the operator except in a rough way. Much of the irregular and variable action of shoes under test has been attributable to these two variables, and it would be highly desirable if they might be entirely eliminated from the problem. To do so, however, would entail an unwarranted expenditure of time. In the experimental and commercial tests which have been run so far, it is customary to cool the shoe and the wheel after every two or three applications of the brake shoe, and to apply sandpaper or emery and a dry cloth to the wheel immediately after each application. By these means the variables mentioned are kept within reasonable bounds, but they are by no means eliminated.

The effect of pressure and speed upon the coefficient of friction has already been made the subject of investigation by the M. C. B. committee, and much valuable information has been published in its reports. With a view of supplementing this work, and, in addition, to determine the effect of the temperature, the tests of which this paper is the record were made. The M. C. B. soft cast-iron "A" shoe, and the M. C. B. hard cast-iron "B" shoe, were chosen for this work since they have become, as already explained, standards of reference. While the action of shoes of different composition under various conditions of testing will vary somewhat from the results herein recorded, it is expected that these results will serve as an indication of what may be expected under like conditions from the majority of metal brake shoes.

Effect of Change in Pressure upon the Coefficient of Friction.—With a change in the normal pressure of the shoe upon the wheel, the coefficient of friction decreases as the pressure increases, within the limits of the tests. The rate of decrease is about the same for all speeds, except at 10 miles per hour, at which speed the coefficient is slightly less than that at 20 miles per hour under light pressures and considerably less under heavy pressures.

Effect of Change in Speed Upon the Coefficient of Friction.—The coefficient of friction of a soft and a hard cast-iron shoe with a change in the initial speed, decreases with increase of speed, except from 10 to 20 miles per hour, between which points it increases slightly. This seems to conflict with the observed behavior of a shoe during a single stop. The coefficient is generally nearly constant from shortly after the start until just before the stop, when it rises to from 1½ times to twice the average value. This takes place with a rate of decrease of speed which is nearly constant until near the stop when it greatly increases.

Effect of Change in Temperature Upon the Coefficient of Friction.—The investigations on the effect of temperature were undertaken for the purpose of finding a partial explanation for the very considerable variations which frequently occur in the results of brake shoe tests under identical conditions and which it has seemed impossible to avoid even when exercising the utmost care. Such differences often amount to 2 or 3% with a value of the coefficient of friction of, say, 25%, and as has been stated, they have been attributed to two causes—variations in the temperature of the rubbing surfaces and variations in the comparative roughness or smoothness of those surfaces. So far as the writer is aware, no reliable information has been obtained heretofore on the effects of temperature, a fact which is easily explained by the difficulties attending such investigations. In fact, it is wellnigh impossible to carry out the experiments with a great degree of refinement or to arrive at other than general conclusions. This, however, has been done in the investigation under consideration, and the general conclusion reached is put forth with confidence as one which is accurate for all practical purposes.

The tests upon which the conclusion is based involve ranges of temperature of the shoe up to 1,500° F., speeds

*Abstract of a paper presented at the meeting of the Western Railway Club, Sept. 18.

†Assoc. Prof. Experimental Engineering Purdue University, Lafayette, Ind.

of from 40 to 60 miles per hour, and normal pressures of from 2,800 lbs to 6,840 lbs. They also involve continuous runs of about five miles in length and from five to ten minutes in duration. It is believed that the range of temperature mentioned is sufficiently high to embrace all but the most extreme conditions of service. The term, "temperature of the shoe," as here used, is more accurately defined as the temperature of two points on the center line of the face of the shoe and near either end. It is obviously impossible to measure the average temperature of the whole shoe while running. Two points of measurement, as just noted, were chosen to represent the average temperature of the shoe. In four continuous tests the wheel was run at a constant speed of about 40 miles per hour, and the brake shoe pressure was 2,808 lbs. Both shoe and wheel were cold at the start. Successive readings were taken, during the run, of the temperature of the trailing end of the shoe, and these are plotted with the coefficient of friction for the same instant. The curve of temperature of the shoe rises during the run to several times its orignal value, while the coefficient of friction changes but little. The curves show that the coefficient of friction is practically a constant, while the temperature of the shoe varies through a wide range.

At no time did the shoe heat up uniformly over its entire rubbing surface. The point of maximum temperature during the first part of the tests, particularly, shifted from the center to either end and back again for no apparent reason and with no observable regularity. Readings taken from both ends in quick succession would sometimes show the leading end hotter and sometimes the reverse, although at any time the difference between them was not great. The general form of the temperature curve may be explained as follows: Immediately after the shoe is applied to the wheel, its temperature rises to about 500° F. In this time the wheel, being of greater mass, has remained practically cold. At this point the shoe begins to impart heat rapidly to the cold wheel, thereby keeping its own temperature down, until the wheel has been heated up and the tread has acquired a comparatively high temperature, after which the temperature of the shoe again increases.

In the continuous tests just described, the initial temperature conditions of the shoe and wheel were the same. Both were cold. To show that variations in the initial temperature does not lead to different results, the wheel was brought to rest from a 35-mile speed under a continuous brake-shoe pressure of 6,840 lbs. The initial temperature of the shoe varied from about 200° to 600° F. The temperature of the wheel varied also, following approximately the temperature of the wheel. The tests were run in several series, each series consisting of three or four tests run after the other, the final temperature conditions of one being the initial conditions for the next, and so on. The conclusion drawn from these results confirms the one already stated: that within the limits of the tests the temperature of the rubbing surfaces does not affect the coefficient of friction.

Summary of Conclusions.

(1) The coefficient of friction of brake shoes decreases with increase of pressure.

(2) The coefficient of friction of brake shoes decreases with increase of speed, except from about 10 to 20 miles per hour, between which speeds it increases slightly.

(3) The coefficient of friction of cast-iron brake shoes is practically constant with variations in temperature of shoe and wheel within the limits of the experiments.

Suggestions as to the Character of the Proposed M. C. B. Specifications.—In view of the variable action of the majority of brake shoes while under test, it seems to the writer that it would be unwise to attempt to specify very narrow limits for the frictional qualities of shoes. A possible plan would be to choose some standard speed (or, possibly, two speeds) and prescribe a range of performance for different pressures within which the mean coefficient of friction of all shoes must come. In order further to insure a sufficient degree of uniformity in the friction of each shoe during the length of the application, it should be specified that the coefficient of friction at a certain number of feet, after the application commenced, should not be less than a certain percentage of the mean coefficient of friction, and that the coefficient of friction at a certain number of feet from the stop should not be more than a certain percentage above the mean coefficient of friction, and should be less than a certain fixed limit. This arrangement would provide an element of elasticity which would cover the unavoidable variations in the results of tests, and at the same time would secure a degree of uniformity which would, in great measure, remedy existing evils.

SCREENS AND SCREEN LIFTERS; METROPOLITAN WATER-WORKS, BOSTON AND VICINITY.

By Chas. W. Sherman, Assoc. M. Am. Soc. C. E.*

With any surface supply of water, it is necessary to use a screen between the distributing reservoir and the pipes in order to prevent fish, leaves and other coarse suspended matter from passing into the distribution system. The Metropolitan Water Board has recently settled upon a standard design of screen, based on careful study as well as many years of experience with Boston's water supply, and has also adopted a mechanical device to enable one man to handle the screens when they are removed for cleaning. The screens and auxiliaries are shown on the accompanying drawings.

The screens used formerly on the works had a mesh which had proved too coarse. A copper netting, having six meshes to the inch, has been adopted for the standard screen, and has been perfectly satisfactory. The frames of these screens are of white pine, in order to be as light as possible, fastened with treenails. The copper netting is securely stapled to the frame on the side which is to go upstream, and covered by a ½-in. board or cover strip for protection. A most important part of the screen is the "dirt-catcher," a wire basket of the same netting as the screen itself, which is fastened to the bottom of the frame of each section. It is intended to catch whatever material drops from the screen while it is being raised, and has been so successful as to indicate that without it, much of the material retained by the screen is washed into the water again during the process of raising.

The present standard design for this dirt-catcher is shown by Fig. 1. It will be noted that each section of screen is fitted with two lifting hooks, instead of the ordinary eye-bolts; these are to engage with the latch of the lifter, but can also be used with the ordinary stop plank hooks.

The first mechanical lifter was designed for handling heavy sections of stop planks in the gate-house at Sudbury Reservoir, which is 65 ft. deep. The latches were of the "ice-tong" pattern, working in a plane at right angles to the frame, and engaging with cast lugs bolted to the sides of the stop planks. This kind of latch could not be used for the screens, as the openings in the floor would not pass the "ice-tongs," so a bell-crank latch was designed. A lifter, slightly different from the present standard, has been in use for nearly two years, and has given good satisfaction. It is operated by a chain hoist, the apparatus being powerful enough so that one man can handle the screens, even though they were so choked so as to admit a difference in head of 1 ft. between the two sides of the screen, in which case the friction would be considerable.

The experience with this earlier lifter developed but two defects: The lead counterweight on the latch was too heavy, and the screws by which it was fastened to the bell-cranks are easily jarred loose. It was also found that the two upper guide wheels in the earlier lifter were not necessary and they are omitted in the present standard design, as shown by Figs. 5 and 6. A number of these lifters are now in use in various gate-houses on the Metropolitan Water-Works.

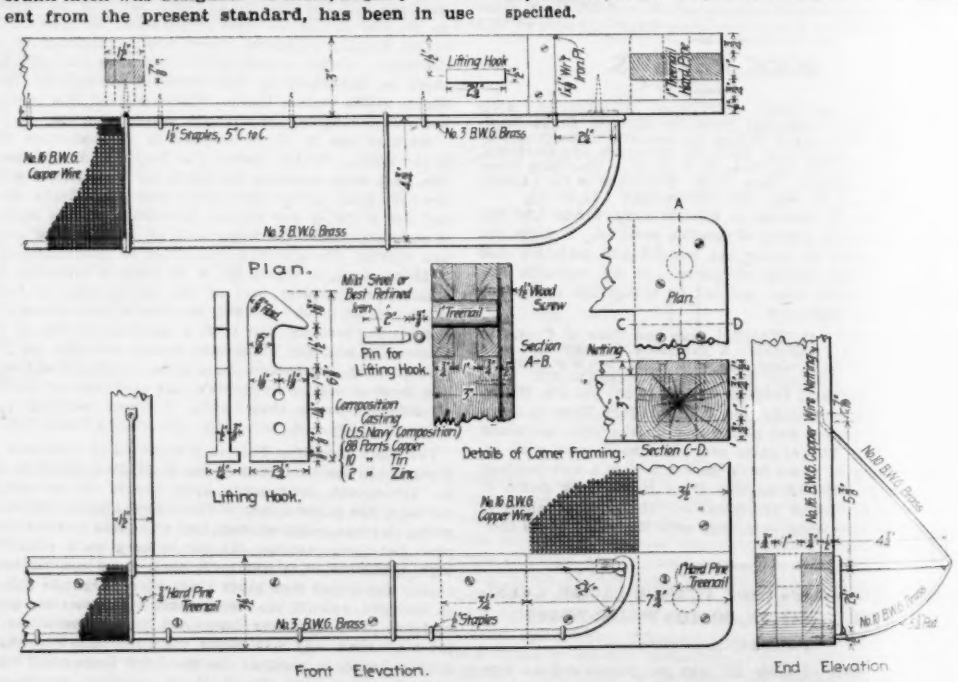


FIG. 1.—STANDARD GATE HOUSE SCREENS, METROPOLITAN WATER-WORKS.
F. P. Stearns, M. Am. Soc. C. E., Chief Engineer.

*Assistant Engineer Metropolitan Water Board, Boston, Mass.

ANNUAL CONVENTION OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The annual meeting of the association was held at Rutland, Vt., Sept. 19 and 20, being preceded by an excursion through Lakes George and Champlain. In his annual address, Mr. B. I. Cook, Woonsocket, R. I., the president of the association, stated that the net gain in membership during the year ending June 1, 1900, was 24, while the average net gain for the past five years had been 35. Less than 25% of the water-works in New England are represented in the association. This is partly due to the fact that many superintendents of small works cannot afford to pay their expenses to the conventions. It would be money well invested for the towns and cities to pay the expenses of representatives at the conventions. The mere reduction of water waste, due to what would be learned at the conventions, would more than repay the cost of attendance. Mr. Cook hoped that the association would adopt a standard specification for cast-iron pipe and would investigate pipe coatings. He was satisfied that coatings are not so good now as formerly.

The report of the treasurer, Mr. L. M. Bancroft, showed that the balance in the treasury had decreased during the past year from $2,712 to $1,240. The report of the secretary, Mr. Willard Kent, showed a total membership on June 1, 1900, of 519, divided as follows: Active, 519; honorary, 5; associate, 70.

The report of the junior editor of the "Journal," Mr. Chas. W. Sherman, Assoc M. Am. Soc. C. E., showed that the total cost of the "Journal" for the past year was $1,954, while the total revenue was $1,607, making a net cost of $347. The regular circulation was 640 copies, of which 594 went to members and 46 to subscribers. Authors of papers are furnished with 50 reprints, free, and additional reprints at cost.

The revised constitution, commented on in our issue of Sept. 13, was adopted, with an amendment providing that members hereafter elected should be transferred to the associate list on engaging in the selling of water-works supplies. The original draft provided for the dropping of any member, old or new, who should go into the business specified.

Invitations were received asking the association to hold its next annual convention at Indianapolis, Ind.; Atlantic City, N. J., and Yonkers, N. Y. They were referred to the executive committee, which, under the new constitution, decides the places of meeting.

Bacterial Methods Used in England for the Treatment of Sewage, so as to Prevent the Pollution of Streams.

By Prof. Leonard P. Kinnicutt.

This was a most admirable review of the development of sewage purification from the start to the present time,

with particular reference to the so-called bacterial methods now attracting so much attention in England and America. Intermittent filtration at Marlboro, Mass., removes more organic matter than the septic tank and double contact beds in the experiments at Manchester, Eng., but intermittent filtration requires a much larger area. Something acting on the same principle as the septic tank was used at a boarding school in England as early as 1858, but Mr. Cameron, of Exeter, Eng., was the first to develop the septic tank scientifically and give it the name it now bears.

The scum on the septic tank seems to consist largely of anaerobic bacteria. It takes five or six weeks for this scum to form in a new tank, and to get good results, but it has been found at Huddersfield, Eng., that scum from an old tank can be applied to a new one and bacterial action secured in three or four days.

It is not a very long step between a closed and an open tank. The results are about the same in each case, so that covering or not is a matter of temperature, the same as in covering sand filters. The effluent from septic tanks does have a decided odor.

We may yet find that while septic action is due primarily to anaerobic bacteria the direct cause of the changes effected are chemical, through the action of the enzimes, which are the products of the decomposition of organic matter. No septic action can be secured in one hour; 12 hours are needed and 24 are better. It is still an unsettled question whether sewage containing large quantities of acids and iron salts can be treated in septic tanks.

Great claims are made for some of the continuous systems of filtering sewage, but they have not yet been proven.

In discussing the paper, Mr. Rudolph Hering, M. Am. Soc. C. E., highly complimented the author for his clear and concise presentation of the subject. In a recent visit abroad, Mr. Hering had been greatly disappointed in what he saw and heard at the various places where the new processes are being tried. In every case excuses were made for the way the work was going on just at that time. He found that the clay ballast and other soft filtering materials soon deteriorated by going to pieces, or otherwise became unsuitable for use, and concluded that harder substances, like sand and gravel, were preferable. He thought the so-called bacterial processes were very promising.

Filtration Experiments at Pittsburg, Pa.

By Morris Knowles, Assoc. M. Am. Soc. C. E.

A large number of lantern slides were shown by Mr. Knowles, consisting of views of the plant in question and tables of results. Since the special commission stopped its investigations in September, 1898, the board of public works has continued to operate the station. Mr. Knowles believed that the platinum-wire test for turbidity does not fully determine the relation between turbidity and the necessary frequency of scraping filters, as measured by the quantity of water treated. A whirling motion in the settling tank supplementing the Jewell mechanical filter seemed to more than offset the larger size of the Warren settling tank.

At the request of the president, Mr. Hering made some remarks on filtration abroad. Europeans are doubtful as to mechanical filtration and most of them believe in slow sand filtration. Mr. N. Simin, Chief Engineer of the water-works of Moscow, Russia, is conducting some experiments on filtration, the results of which will not be available for a year or so. Mr. Simin was favorably impressed with mechanical filtration during his visit to this country a few years ago. The smaller water consumption in European cities and the more certain tenure of office abroad are two decided advantages possessed by engineers there, compared with American engineers.

Uniform Municipal Accounting.

At the request of the president, Mr. M. N. Baker, of the editorial staff of this journal, outlined the recent movement to secure more uniformity in municipal accounts and reports. Mr. C. W. Sherman Assoc. M. Am. Soc. C. E., referred to the tabulation of water-works statistics in the last number of the "Journal" of the New England Water-Works Association. The statistics were drawn from summaries purporting to be in accordance with the schedule adopted by the association. Of the 28 works included, he was assured by Mr. J. E. Beals, senior editor, that no two carried out the plan in the same way. Mr. Beals thought the schedule should be simplified and abbreviated. Mr. Sherman suggested that perhaps there might be two schedules, one very full, and another much shorter and more general, a summary of the grand summary. On motion of Mr. Sherman, the president was instructed to appoint a committee of three to take into consideration the whole matter of revising the New England schedule and to co-operate with committees from other societies in this work. The committee will be announced at a later date.

Later on, Mayor Hall, of Quincy, Mass., stated that the Auditors' Club of Massachusetts had found that the variations in city charters in that state hindered uniform accounting. The Auditors' Club and the Mayors' Club of Massachusetts hope to secure more uniformity in city charters, and thus in municipal accounts. The Auditors' Club is some six years old and has one or two meetings a year. It has been the means of many improvements in municipal bookkeeping.

Landscape Problems in the Improvement of the Spot Pond Reservoir, Metropolitan Water-Works.

By Frederick Law Olmsted, Jr.

This paper was a valuable one and a unique feature in the program of a water-works convention. It was accompanied by many lantern slides; so many, in fact, that the excellent impression made at the start was in danger of being partially obliterated by a repetition of detailed photographic views and grading plans. Fortunately, these defects will not appear when the paper is published in the "Journal," since only a few representative views can be presented in the space there available.

Mr. Olmsted first spoke of the need of co-operation between different professions in carrying out any great public work. The results obtained by such co-operation in the development of buildings and accessories at the Chicago exposition were cited as showing its value. The firm of landscape architects with which Mr. Olmstad is connected was called in to consult with the engineers, Messrs. Stearns and Brackett, about the lanscape features of the Spot Pond reservoir. This reservoir is located in the Middlesex Fells, a part of the Metropolitan Park system. Its water level has been raised 9 ft. and a large amount of work has been done to clear the bottom of muck, all of which of necessity changed the shore line of the reservoir. The function of the landscape architects was to see how these changes could be effected with the least sacrifice of beautiful natural features and the greatest addition of artificial beauties which should be as natural as possible. The engineers submitted a general plan of the proposed changes to the landscape architects and the latter suggested the best methods of carrying out the work, from their standpoint. Then the engineers took the cost and the effect on the engineering features into consideration, and so the co-operative work went on. The views showed the landscape results obtained, and also some striking contrasts in the form of other reservoirs, built wholly regardless of artistic effect. The paper, or address, was so long that no time was available for discussing it.

Owing to the absence of the authors and encroachments upon the regular program due to excursions, the papers by Messrs. F. A. W. Davis and W. J. Sando, on "Electrolysis" and on the test of the new 30,000,000-gallon pumping engine at Chestnut Hill, respectively, were postponed until a later meeting, as was also the topical discussion of "Service Boxes." Two other papers on the program, by Messrs. R. S. Weston and John H. Washburn, were omitted through absence of the authors, and their failure to forward the papers.

During the stay in Rutland many of the marble quarries in Rutland and its vicinity were visited, and also the Howe Scale Works and reservoirs on the stream from which the water supply of Rutland is drawn. A list of exhibitors is given under "Industrial Notes" in our Supplement. The members and guests registered numbered about 100.

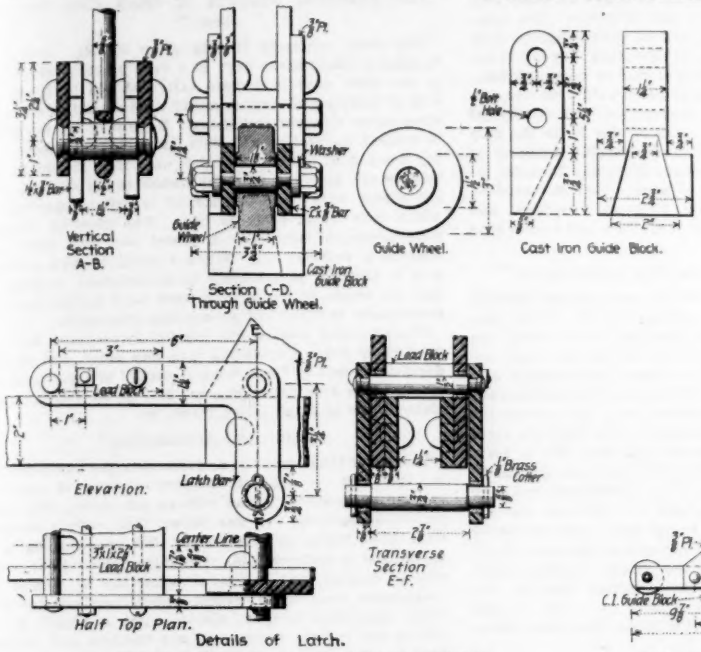


FIG. 3.—DETAILS OF SCREEN LIFTER.

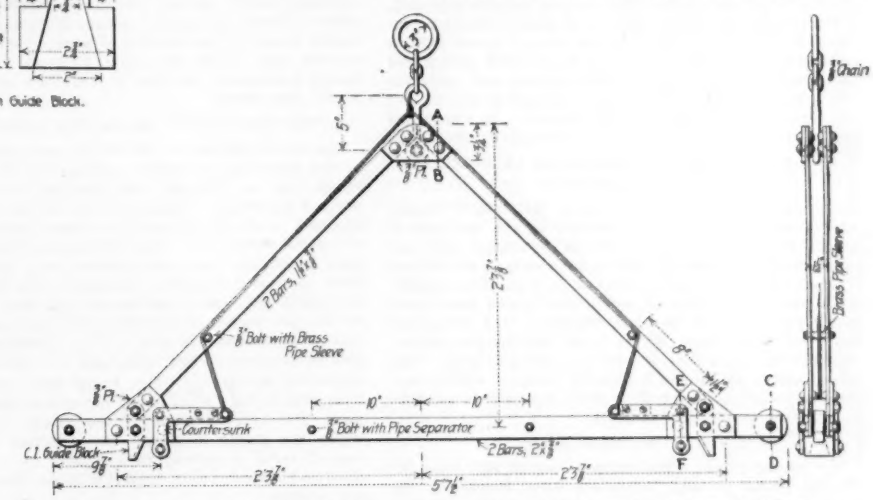


FIG. 2.—ELEVATIONS OF SCREEN LIFTER, METROPOLITAN WATER-WORKS.

ANNUAL MEETING OF THE NATIONAL MUNICIPAL LEAGUE.

The sixth annual meeting of the National Municipal League was held at Milwaukee, Wis., Sept. 19, 20 and 21, the headquarters being at the Pfister Hotel. The first session was called to order at 3 p. m. on Wednesday. Mr. Charles Richardson, First Vice-President, being in the chair, and about 50 members and guests present, including several ladies. After a few opening remarks by the chairman, short addresses of welcome were delivered by Mr. John A. Butler, on behalf of the Municipal Association of Milwaukee, and by Mr. J. B. Doe, Assistant City Attorney, on behalf of the Mayor. The latter pointed out that a city attorney should be a first-class lawyer who has made a specialty of municipal law and affairs, but that it is practically impossible to have such an officer under the present system of changing all heads of departments with each change in administration. A short address was also made by Mr. Charles J. Bonaparte, of Baltimore.

"A Year's Municipal Development."

A general report on progress in "good government" affairs was then read by the Secretary, Mr. Clinton R. Woodruff, of Philadelphia. An abstract of this was printed in our last week's issue.

Mr. George Burnham, Jr., the Treasurer of the League, then presented his report, showing receipts of $2,642 and expenditures of $2,529 for the year. A motion was made to adopt this, but Mr. Bonaparte suggested that for an association advocating business-like methods it would be more appropriate to appoint a committee to audit the accounts. This action was taken.

Mr. Fred. Tuke, Secretary of the Taxpayers' League of Cincinnati, briefly described the preseit position of the movement in favor of enacting the Ohio municipal code into a law. The last legislature adopted it, but subsequently reconsidered the vote, so that the matter is still unsettled. The greatest obstacle to its adoption is a lack of harmony among the reformers, who hold different opinions regarding the importance of certain parts of the code.

The nominating committee then presented its report, recommending all the officers for re-election, which was adopted. The officers are as follows: President, James C. Carter, New York; Vice-Presidents, Charles Richardson, Philadelphia; Samuel B. Capen, Boston; Thomas N. Strong, Portland, Ore.; H. Dickson Bruns, New Orleans; Edmund J. James, Chicago. Secretary, Clinton Rogers Woodruff, Philadelphia; Treasurer, George Burnham, Jr.,

Philadelphia. Executive Committee: Charles J. Bonaparte, Baltimore; George W. Guthrie, Pittsburg; George W. Ochs, Chattanooga; Hector McIntosh, Philadelphia; Joseph A. Miller, Providence; Oliver McClintock, Pittsburg; Frank N. Hartwell, Louisville; Harry A. Garfield, Cleveland; William G. Low, Brooklyn; Dudley Tibbits, Troy; John A. Butler, Milwaukee.

The evening session was held at the Pabst Theatre, but the attendance was extremely small. Mr. Irving M. Bean presided. The first paper, by Mr. Joshua Stark, President of the Wisconsin Bar Association, on "The New Municipal Program and Wisconsin Cities," dealt with the provisions of the model charter as proposed by the League. Among the most important of these he considered the provision which gives citizens and taxpayers the right to bring action to restrain any illegal or unauthorized contract on behalf of the city and to prevent the payment of illegal or fraudulent bills. This is a much-needed measure of protection. As to franchises, while many Wisconsin cities have built their own water and lighting plants, street railways are generally built and operated under franchises granted to private parties. The opinion is gaining ground, however, that the control and use of streets should be retained in the hands of the city, and that all public utilities dependent upon such uses should be provided, owned and operated by the municipality under a wise and conservative government administered upon business principles and free from political and partisan control. It was urged that such a system would result in great public advantage.

"Improper Influence on Legislation by Public Service Companies."

A paper on this subject was read by Mr. John F. Burke, of Milwaukee, in which he referred to the evidence of fraudulent dealings between officials, legislators and representatives of companies, which have become the subject of investigation by the courts and have in some notable cases resulted in prominent public men having been found guilty and punished for such dealings. The companies have corrupted voters, bribed juries and bought legislators, but the blame does not rest entirely upon them. The office-holders, voters and legislators who are willing and eager to be bought, using their office or power as a means of extortion, are equally culpable.

"Primary Election Laws."

The closing paper of the evening was by Mr. Amos P. Wilder, Editor of the "Wisconsin State Journal." He spoke of the attempts made in various cities to effect reforms in elections, and the desirability of introducing methods by which nominations can be controlled by the mass of the citizens instead of by bodies of self-interested men who are looking for their own interests rather than for those of the community at large. Nomination by petition rather than by the primary was advocated.

On Sept. 20, three papers were presented dealing with the municipal program (more commonly known as the "model charter") drawn up by the association. The discussion on the papers was taken up afterwards, but was very limited. One member thought that nomination by petition was as liable to be controlled by ward bosses and party managers as is the system of nomination at the primaries.

"Does the New Municipal Program Confer Dangerous Powers on the Mayor?"

In this paper, Mr. Charles Richardson (Philadelphia) urged that under any system of government there must be an element of danger to the rights of those who are governed, and that the aim should be to see that the powers conferred are safeguarded as far as possible. The purpose of the paper was to show that this is done under the provisions of the municipal program of the League, while the powers conferred are not too great in view of the duties to be performed.

"An Essential Safeguard to Executive Responsibility."

The author of this paper was Mr. George McAneny (New York), Secretary of the National Civil Service Reform League, and the purport of the paper was to show the far-reaching advantages of the civil service system in the selection of municipal employees. Much of the time of the heads of departments is now wasted in dealing with applicants for office, with more or less political backing, and persons employed under this system are rarely properly qualified for the positions they hold. Various means of getting round civil service requirements were noted, one of the worst of these being the establishment of positions exempt from these requirements. The civil service system as properly carried out was described in some detail, and it was claimed that even laborers should be classified and registered.

"Some Essential Features of the New Municipal Program."

This was the third paper, and was read by the author, Mr. John A. Butler (Milwaukee). He took up the discussion of several objections which have been made against this program, or "model charter," and against its provisions, and showed that there was very little basis for these objections. It was not evolved or created by the committee which prepared it, but represents various methods and practice in all parts of the country which have been found by experience to be practicable and advantageous. He deprecated the ward system of representation, under which each member of the council looks after his own ward interests and bargains with fellow members to vote for his bills if he will vote for theirs, regardless of the relation of these measures to the welfare of the city as a whole.

"The Influence of Public Service Companies Upon City Government."

In this paper the Rev. Dr. Washington Gladden, a member of the city council of Columbus, O., dealt with the illegal relations between representatives of the companies and of the city. He considered that there is too great a tendency to regard money-making as above all other considerations, even above honor and principle. The companies claim that they must protect their property from the attacks of a certain class of legislators, but lay themselves open to attack by their readiness to meet and compromise with such men. He urged that public service corporations were necessarily monopolies, and considered public ownership of municipal monopolies to be the only effectual remedy for the present disgraceful condition of affairs. Under the present system, enormous financial interests favor the maintenance of weak or bad government, because they could not obtain from an intelligent and honest government the class of franchises and concessions which they desire.

"The Government of the City of Glasgow."

The city of Glasgow is well known as a leading example of the municipal ownership system, and Dr. Alfred Lazenby, now of Chicago, described at some length the various directions in which the city authorities have undertaken work usually left to private corporations and charitable institutions. Only rate-payers (men and women) have votes, and taxes are assessed upon the rental instead of upon a haphazard valuation; only half the rates are levied on houses renting for less than $50 a year, so that the burden of taxation is thrown upon the shoulders of those who can best bear it. The street railways give an excellent service, with fares of 1 to 6 cts., and are financially successful, while wages have been increased from time to time without any demand on the part of the men. Dr. Lazenby preferred the British system, under which the Mayor is simply the presiding head of the council (with a casting vote in case of a tie), to the American system, under which the Mayor has large executive powers.

"Representation of Different City Interests in the Council."

In this paper, Mr. William D. Foulke, of Richmond, Ind., discussed the plan of representation in the council by geographical location, or the ward system. This system cannot give a really representative government, as it limits the number of good men available and must introduce an element of a lower class as representatives of certain wards or districts. These ward representatives regard themselves as such, and not as representatives of the city. Under this system, also, many voters are disfranchised. The author considered that business representation would soon supersede political representation.

In the evening, a reception was given at the Atheneum by the ladies of the Milwaukee College Endowment Association. Addresses were made by Messrs. Bonaparte, Woodruff and Foulke, and by Mrs. M. A. B. Conine, of Denver, formerly a member of the Colorado legislature. The addresses, as was natural, had for their principal theme the power of women's influence in municipal affairs.

At the morning session on Sept. 21, the first paper presented was by Prof. Samuel E. Sparling, Secretary of the Wisconsin League of Municipalities, on

"The New Municipal Program and Small Cities."

In this paper it was claimed that the states of the middle West are states of small cities, which sustain an interest before the people hardly less than that of large cities, but which are largely neglected in discussions upon municipal government. In Wisconsin, less than 5 cities out of 105 would be classed as large cities.

"Local Transportation and Its Relation to the Welfare of the Municipality."

This paper, by Mr. Geo. E. Hooker, of Chicago, set forth in an interesting manner the relation of street railway transportation to the citizens, showing that the poorer classes who travel daily for 50 or 52 weeks in the year pay more than the wealthier people who can use cabs and carriages occasionally and are out of town during a part of the year. Mr. Hooker did not favor payments to the city by the company, but rather the graded fare system generally adopted in England and already introduced to some extent in this country. Trans-urban lines were also shown to be of greater public benefit than these which, like all the Chicago lines, terminate in the "downtown" district. The conditions of street railway accommodations in various cities were described, with a view of pointing out the fallacy of the claim that capital will not invest in such an industry where it is subject to strict control. The accommodation and service provided in Washington and Boston, as compared with such cities as Chicago, were declared to abundantly disprove this idea. The franchises should not have any fixed period of duration, but should be contingent upon good behavior.

The discussion on this paper was opened by Mr. G... C. Sikes, Secretary of the new Street Railway Commi... of the Chicago city council. He dealt more particu... with the questions of labor, and believed that the c... should embody in the franchises requirements as to m... mum wages, maximum hours of work and the right of men to belong to labor unions. He also favored c... pulsory arbitration, but thought that the usefulness certain state boards of arbitration is destroyed from fact of their having become mere political bodies. marks expressing ideas on similar lines were made by few other speakers.

"The Essential Element of Good City Govern... ment."

The ideas expressed in this paper by Mr. Charles Bonaparte (Baltimore) were of a very practical charact... to the effect that immediate action should be taken as well as talking and writing about what should or could done under different conditions. Reformers are too pro... to content themselves with this latter class of energy, b... the demand of the times is that each man should do t... best he can now and with the means at his disposal, a... not simply wait for better means or better opportuniti... which may never come to him. The question of g... government is essentially a moral one, and only inc... dentally a political one. When a self-governing commu... nity is afflicted with chronic misgovernment, it must be that the people do not wish or work hard enough for good government to make bad government impossible.

The afternoon session was but lightly attended, but was marked by more discussions than any other, and in fact developed a sort of "experience meeting" of exceptional interest. The first paper was by Mr. M. N. Baker, Associate Editor of Engineering News, on

"Municipal Accounting."

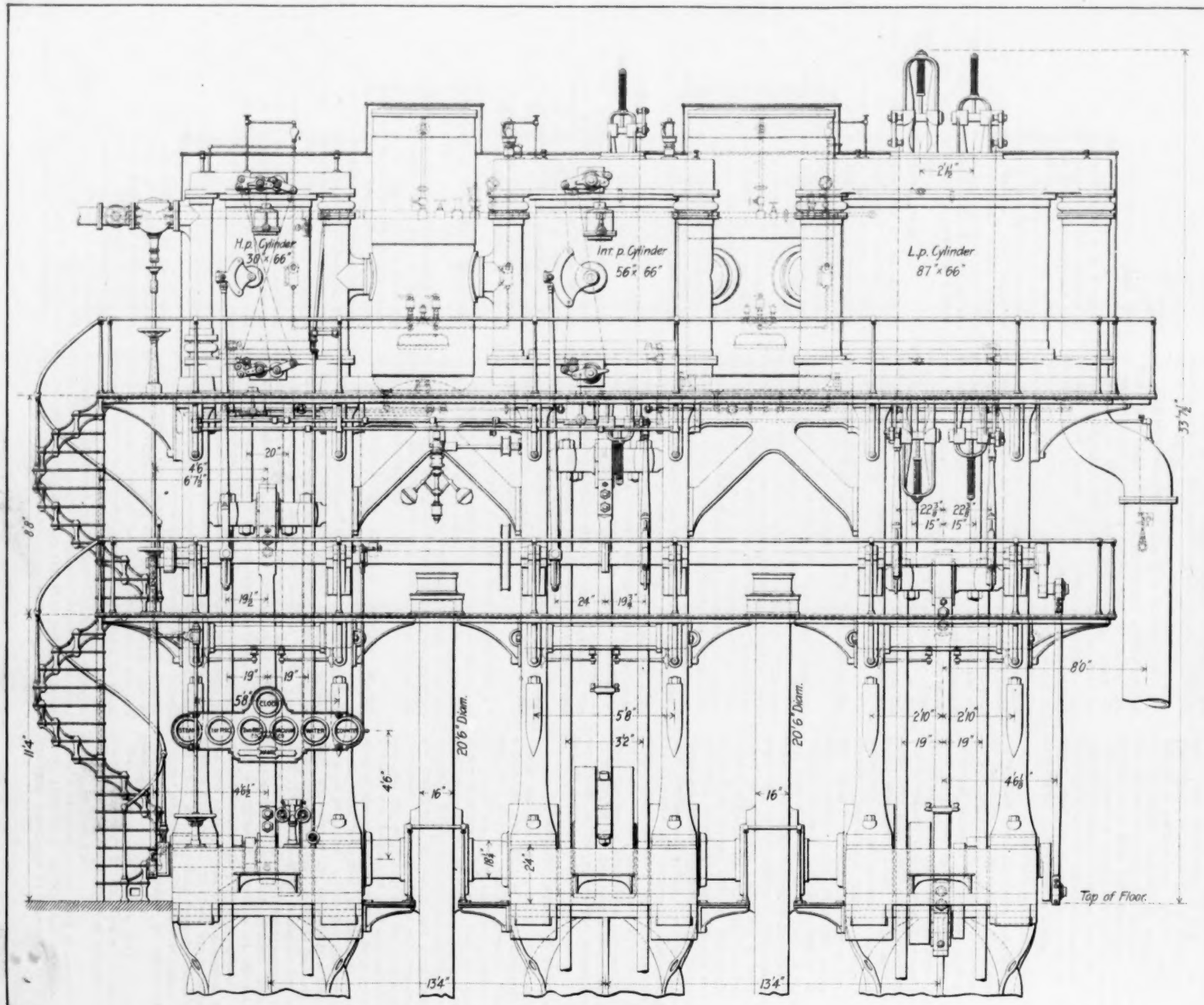
The paper itself was short, presenting the developments in the way of adopting uniform systems of accounting for water-works, street railway companies, and other municipal services. It was shown that various associations have taken up this matter, but are working in a specialized or isolated field. The main object of the paper was to suggest that a general committee be formed by committees from these several associations and the National Municipal League, whose object it should be to reduce the various systems to one common and uniform system. Two written discussions were presented, one by Mr. James B. Cahoon, President of the National Electric Light Association, in which the above suggestion was warmly endorsed. The other was by Mr. H. B. Henderson, State Examiner for the State of Wyoming, who also endorsed the suggestions and described the system of state supervision of accounting in Wyoming. These were followed by a general discussion, in which the defects of present systems, the evils and scandals resulting from the lack of system, and the supervisory methods which have been instituted in several places were mentioned. The discussion drifted somewhat from municipal matters and dealt with the accounting of county and township officials, and of public and semi-public institutions, such as hospitals, insane asylums, etc. It was very clearly shown that there is very great need of uniform accounting systems, and also of supervision and publication of accounts. On motion of Mr. Woodruff it was resolved to appoint a committee to carry out the suggestions made in Mr. Baker's paper.

"Commercialism in Politics."

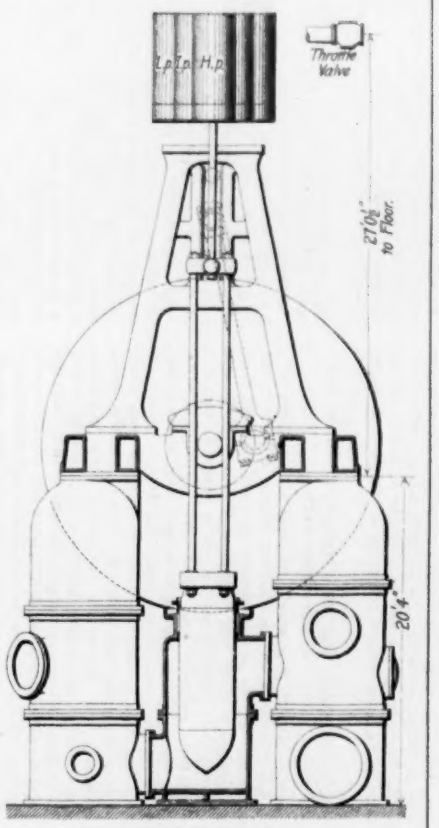
This was the closing paper of the meeting, and was written by Hon. Bird S. Coler, Controller of New York city, who, however, was not present. The paper showed that people are paying so much attention to personal affairs and money-making that they are departing from the rules of conduct laid down by the founders of the constitution. Public interests are sacrificed to private ends, and franchises, legislation and even judgments can be purchased. The root of this evil was said to be in the fact that the machinery for the maintenance of political divisions has become so vast and complicated that large sums of money are required to keep it in motion. As a result, when individual or corporate interests seek the favor or protection of the city government, they go to those who control the office-holders instead of to those whose votes make laws or whose decisions interpret legislation. The masses of the people are honest, and the remedy for the existing conditions was stated to be the arousing of an intelligent public opinion. This paper brought forth an animated discussion on various political matters, particularly in regard to primary elections, their evils and their correction, and numerous examples of experience were cited. The hour was growing late, however, and when one gentleman remarked that he could see no way out of the difficulty, the chairman remarked that in view of that fact it would be appropriate to close the meeting.

Two paper on the program were not read: "The New Duluth Charter," by Mr. Henry F. Greene, of Duluth, Minn., and "Municipal Political Parties," by Dr. Milo R. Maltbie, of New York.

The convention closed with a banquet at the Pfister Hotel, tendered to the National Municipal League by the Municipal Association of Milwaukee.



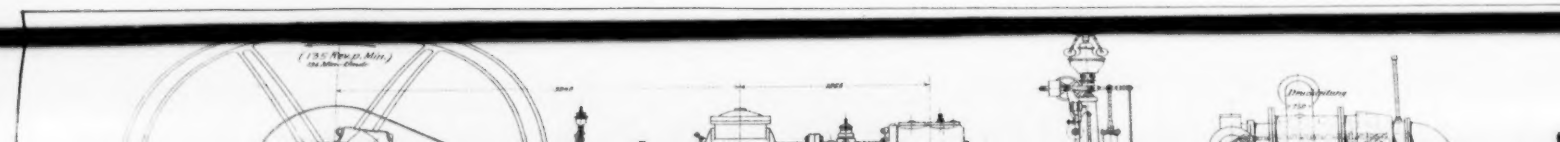
FRONT ELEVATION.

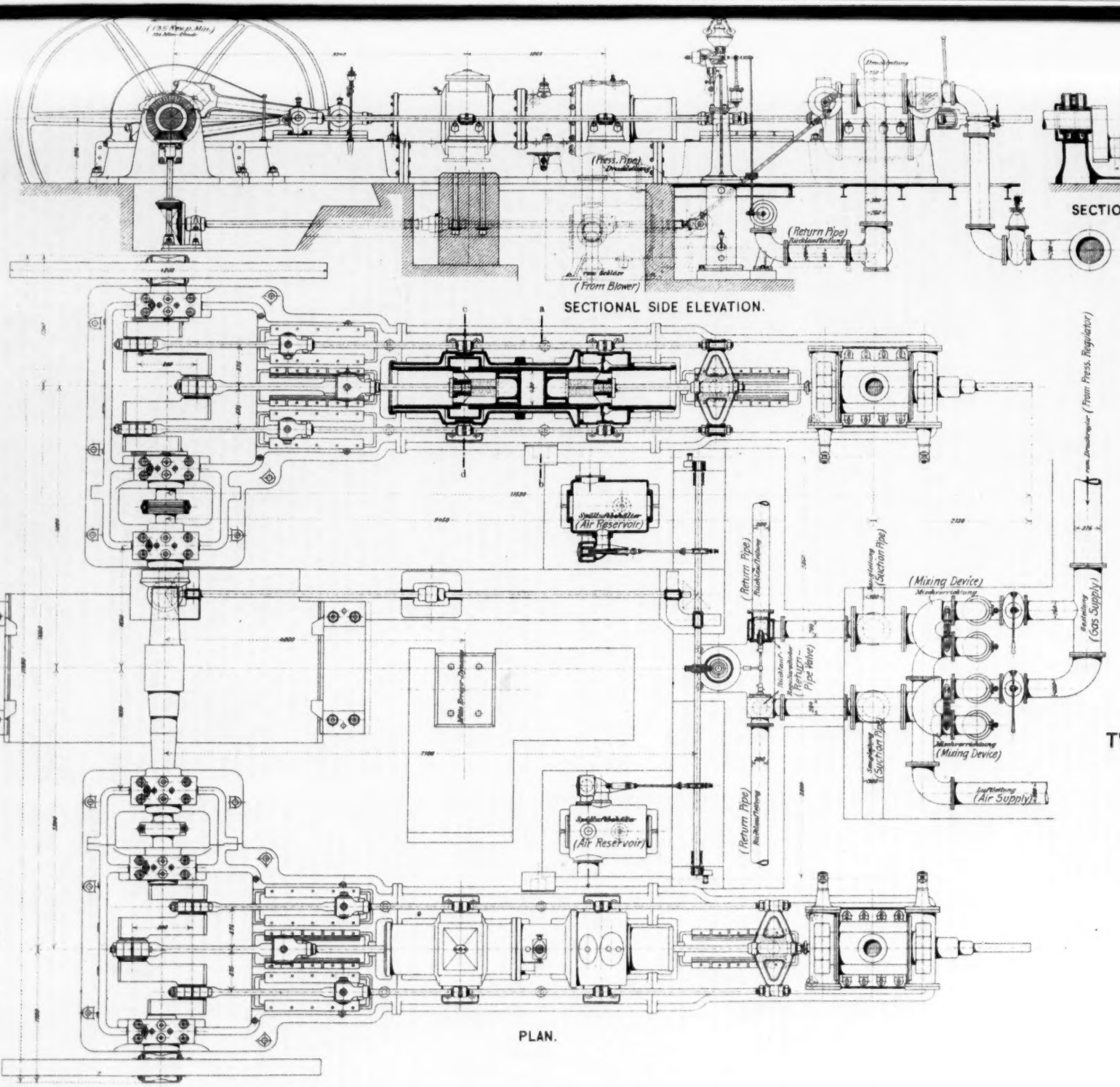


CROSS SECTION.

TRIPLE-EXPANSION PUMPING ENGINE CHESTNUT HILL HIGH-SERVICE STATION, BOSTON WATER-WORKS.

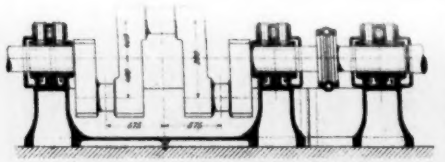
Designed and Built by the
E. P. Allis Co., Milwaukee, Wis.



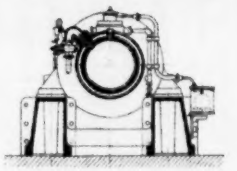


SECTIONAL SIDE ELEVATION.

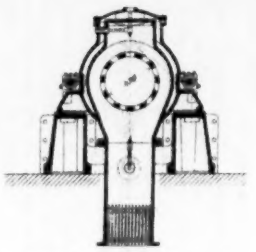
PLAN.



SECTION THROUGH MAIN BEARINGS.



CROSS SECTION a—b.



CROSS SECTION c—d.

TWO-STROKE CYCLE GAS ENGINE OF 600 H.-P.

Built by the

Berlin-Anhalt

Machine Co., Ltd.,

Berlin, Germany.

CHAS. HART, LITH., 38 HENRY ST., N. Y.